Dean&Francis

ISSN 2959-6157

Design of temperature and humidity control system based on Single Chip Microcomputer

Peijin Qin

Abstract:

This paper presents a temperature and humidity control system based on STC89C52, which mainly includes hardware design and software design. Hardware design part completes the electronic components selection, circuit design and debugging, software design part completes the preparation of each function module subprogram and system main program. The system designed in this paper can drive the working state of the back-end equipment in real time according to the temperature and humidity value in the current working environment, so as to effectively control the effect of indoor temperature as well as humidity, so as to reduce the occurrence of aging weapon equipment and abnormal work accidents caused by the temperature and humidity exceeding the predetermined value.

Keywords: single chip microcomputer (SCM), temperature and humidity control, system design

1. INTRODUCTION

1.1 Background

Temperature and humidity(T&H) have played a very important role in our living environment. No matter which city we live in, where we work, we inevitably have a close relationship with T&H. In industrial production, T&H is the most basic and the most common process parameters of all products. In the machinery, petroleum, glass, electronics, chemical industry, metallurgy, cement, steel and other industries are inseparable from the detection and control of the T&H of the production environment. In agricultural production, farmers detect and control the T&H in the greenhouses to achieve crop growth in the seasons when they cannot grow. At present, people are usually using thermometer and hygrometer to collect T&H, through artificial heating, humidification, ventilation and cooling equipment to control the T&H of the environment, but this not only low control accuracy, poor real-time performance, and the operator labor intensity is big, even if some users use semiconductor diode as a temperature sensor, also because of its poor interchangeability, the effect is not ideal.

In view of this problem, this paper studies and designs a temperature and humidity control system (THCS) based on single chip microcomputer (SCM). Through this system, the user can timely understand the changes of T&H in the storage room, the system can automatically complete the automatic alarm after

exceeding the set threshold and control the relay suction sum according to the results of the indoor T&Hvalue and threshold value, and then drive the external equipment to achieve the effect of controlling the T&H in the room.

1.2 Research Objectives

This paper mainly studies a design technology of THCS based on SCM, through the designed THCS to realize the T&H control of a room, to prevent the accident caused by the T&H exceeding the predetermined value.

1.3 Reasons for choosing this topic

My plan for my future career tends to be focused on information technology, and at the same time, I am also an electronic design enthusiast. Therefore, I expect to systematically learn electronic design to change the way we live. After a long period of observation, I found that many warehouse, electronic equipment room and laboratory in my school are lack of THCS. In particular, the network switch is placed in the storage room, with many storage items, easy to cause T&H changes, affecting the service life, safety and stability of the switch. Therefore, I plan to design a T&H control device to solve this problem.

1.4 Outline of the research

This research is divided into six chapters, which are as follows:

The first chapter is the introduction, which mainly discusses the research background and significance of this paper and the development and research status of THCS.

The second chapter is the overall design of the THCS, mainly to analyze the current needs of our school, determine the function of the THCS according to the needs, and then determine the implementation of the structure and function of the THCS.

The third chapter is the hardware design of the THCS, mainly according to the overall scheme, select the components and draw the circuit diagram, design the total circuit of the THCS, so that the THCS can work normally after power.

The fourth chapter is the software design of the THCS, which is mainly programmed according to the overall scheme, using the C language, write the general program of the system and the program of the functional module, so that the THCS can complete the work according to the written program, and realize the function of the THCS.

The fifth chapter is the function test of the THCS, mainly according to the overall plan, complete the design to test and verify the function of the THCS, so as to ensure that the THCS can work normally.

The sixth chapter is the conclusion, mainly to summarize the THCS, put forward the existing deficiencies and improvement measures.

2. LITERATURE REVIEW

2.1 temperature and humidity

Temperature is a measure of how hot or cold it is, which reflects the intensity of the particles moving inside it. In thermodynamics, temperature is defined as the energy per unit of thermal activity of a thermodynamic system (Zhang Fuheng,2007). This definition emphasizes the relationship between the temperature and the moving state of the particles within an object. Temperature measurements are based on the concept of thermal equilibrium, where two objects have the same temperature when they are in thermal equilibrium. Measurement of temperature usually depends on characteristics of certain physical properties varying with temperature, such as the length of metal, pressure or volume of gas an so on(Mang Wanli,1995).

Humidity is a measure of the water vapor content in the air. It can be expressed by the absolute humidity, relative humidity, or dew point temperature. Absolute humidity refers to the mass of the water vapor contained in the air per unit volume, while relative humidity refers to the ratio of the actual water vapor content in the air to the maximum water vapor content that the air can hold at that temperature (Xu Jianzhao,2009). The dew point temperature is the temperature at which the water vapor in the air condenses into dew, which is related to the relative humidity and temperature of the air.

T&H are interrelated physical quantities. For example, the higher the relative humidity in the air at the same temperature, the wetter the air is. Furthermore, changes in temperature can affect the ability of air to accommodate water vapor, thus affecting changes in relative humidity. In practical applications, understanding the relationship between T&H is crucial for weather forecast, agriculture, built environment control and other fields.

2.2 single chip microcomputer (SCM)

single chip microcomputer is a kind of integrated circuit chip, it adopts very large-scale integrated circuit technology, will have data processing ability of the CPU, ROM, RAM, timer / counter, a variety of I / O port. (Li Xiaoning,2015). This high integration design makes the MCU with small size, low cost, powerful function and other characteristics, so it has been widely used in industrial control, automation equipment, household appliances, medical equipment, and other fields (Yin Xiuzhuang ,2018).

ISSN 2959-6157

The application range of SCM is very wide, from the basic control function to the complex system integration (Liu Tiezhu,2019). For example, in electronic technology, SCM is used to realize pulse width modulation and in the design of winding frequency conversion governorin intelligent electronic products (Gong Zhanxia,2016), SCM technology is used in energy saving control, language interaction, intelligent monitoring and vehicle monitoring system(An Yang,2022). In addition, MCU is also used in automatic alarm device, vehicle monitoring, language communication and medical equipment development, which effectively improves the market value of products (Liu Cailing,2024).

2.3 Development process of THCS

The development process of THCS can be summarized from the early manual control to the modern automatic and intelligent control system. In the early stage, T&H control mainly depends on manual detection and adjustment, which is not only inefficient, but also easy to be affected by human factors, resulting in low control accuracy(Han Kai,2015). With the progress of science and technology, especially the development of computer technology and sensor technology, the THCSs began to develop to the direction of automation and intelligence.

In 20th century, automated systems based on commercially available T&H indicators and specially built flow-temperature-humidity control modules had emerged (Yang Dong,2013). This marks the beginning of a shift in T&H control technology from manual operation to automatic control. Subsequently, the research and application of T&H independent control air conditioning system is gradually increasing (Wu Shuchuan,2012). This system controls and adjusts the indoor T&H respectively through two sets of independent systems, avoiding the problems existing in the conventional central air conditioning system (Jia Lei,2011, Tong Ling,2006, Li Zhongwang ,2013).

In recent years, with the development of the Internet of Things and big data technology, the THCSs are developing towards a more intelligent and networked direction (Xiao Jiatao,2019). For example, the T&H monitoring and control system based on Arduino SCM not only realizes the low cost and high reliability of general T&H distributed detection control (Barik,2019), but also supports remote control and real-time data monitoring(Aishwarya Karra,2020). In addition, the composition and development of intelligent T&H monitoring system also shows the important role of computer technology and modern sensing technology in the T&H monitoring. These systems generally use T&H sensors, single-chip microcomputer and microcomputer technology to realize the detection and automatic adjustment of T&H.

3. DESIGN OF THE SYSTEM

3.1 Requirements analysis

According to the requirements of displaying the T&H value in the computer room and controlling the T&H in the computer room, the THCS designed in this paper needs to perform several functions:

1) Actual detection and real-time display of T&H. The T&H value is collected by the liquid crystal display T&H sensor.

2) Set the T&H threshold value manually. Through four independent keys to achieve the T&H threshold setting, so that the system is more intelligent and humanized, has a higher use value. The threshold value is stored through the memory chip to realize the function of power loss protection.

3) Control the T&H. When the T&H exceeds the set threshold value, the system automatically alarms, and the corresponding relay absorbs and drives the external equipment and prompts the user through the small light.

3.2 Overall design

According to the functions required by the THCS, the overall design process of the system is shown in Figure 1:

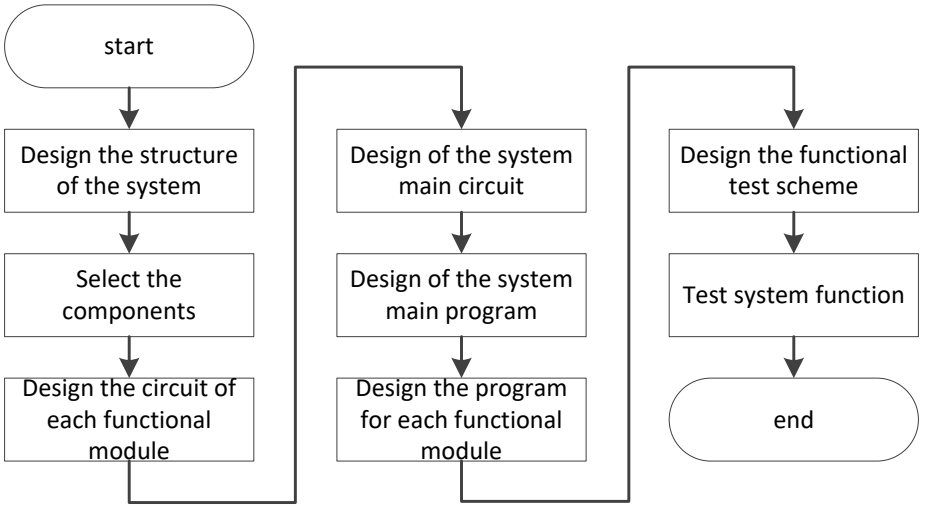

Figure 2.1 Overall design flow chart of THCS

1) Design the structure of the THCS: on the basis of ensuring that the function can be realized, the cost of the system is reduced as far as possible. The structure of the THCS designed in this paper is shown in Figure 2.As can be seen from the figure, the THCS mainly takes the storage and processing of the microcontroller, the display displays the data, the key sets the threshold data, the memory stores the threshold data, the sensor collects the data, and the microcontroller controls the relay and the alarm work.

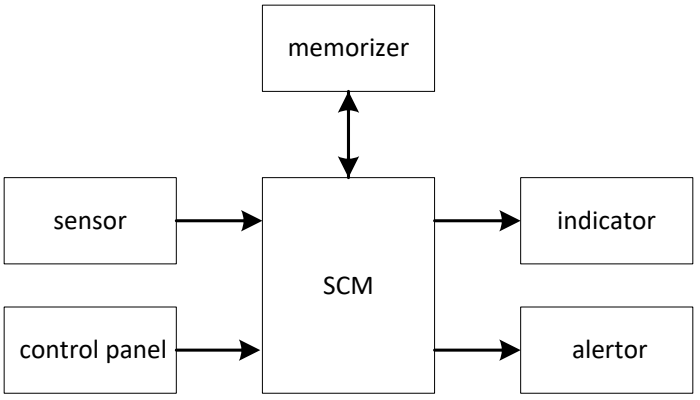

Figure 2 Structure diagram of the THCS

2) Select components: According to the functional requirements of the THCS, the components required to be used mainly include microcontroller, sensor, display, memory, relay, buzzer and power switch. The system is a microcontroller as the core, controlling other components. The ambient T&H value is detected by the T&H sensor and displayed in real time on the LCD display. The T&H threshold is set by four independent keys and stored in the memory, so as to realize the function of storage threshold and power-off protection. By comparing the T&H value detected by the sensor with the set T&H threshold, the corresponding relay suction is controlled to drive the external equipment, and light the indicator light and control the buzzer to remind the user, so as to realize the function of T&H control.

3) Design the circuit of each function module: first, design the circuit of the data acquisition and display module, and design the circuit of the T&H sensor and the liquid crystal display, so that the data acquisition and display module can work normally. Then the threshold input and memory module circuits are designed, by designing the key circuit and the memory chip circuit, so that the number threshold input and memory module can work normally. Finally, the circuit of alarm and relay module is designed. Through the circuit of buzzer and relay, the T&H module of the THCS can work normally.

4) Design the general circuit of the THCS: connect each component with the SCM, reasonable layout, and draw the general circuit diagram of the THCS.

5) Design the main program of THCS: with SCM control as the core, design the main program of THCS, determine the subprogram of THCS, so that the THCS can work nor-

ISSN 2959-6157

mally under the unified control of single controller, and realize the function.

6) Design the program for each functional module: first, design the data collection and display module subroutine, through the design of T&H sensor and LCD display program, so that the THCS to realize the function of detecting and displaying the T&H value. Then, the threshold input and storage module subroutine are designed. Through the program of designing keys and memory chip, the THCS realizes the function of threshold input and storage. Finally, the T&H control module is designed to design the program of buzzer and relay to make the THCS realize the function of T&H control.

7) Determine the functional test scheme of the THCS: after completing the design of the whole THCS, determine a feasible functional test scheme to ensure that the THCS can meet the actual needs of the current college switching room after the test of this scheme.

8) Test and verify the functions of the THCS: test the THCS according to the determined test scheme, and further improve, optimize and improve the problems and deficiencies in the system until the THCS can realize the required functions and meet the expected requirements.

3.3 Hardware design

3.3.1 The choice of components

(1) SCM

The working process of the SCM is the process of constantly executing the instructions. In my design (Zhang Yuwei(2011)) , STC89C52 controller is selected as the core component of this system. It is a classic high-speed and low-interference single-chip computer produced by Hongjing Technology Co., LTD. The STC89C52 is shown in Figure 3.

Figure 3 STC89C52 chip

(2) sensor

The sensor selected in this system is DHT 11 T&H sensor, as shown in Figure 4, which is an integrated digital T&H sensor composed of a temperature measurement element NTC and a resistance type humidity measurement element(Zhang donglin(2010)).

main parameters:

1) Operating voltage: 3.3~5.5V DC

2) Measuring range: temperature: 0~50℃; humidity: 20 ~ 90% RH

3) Measurement accuracy: temperature: ± 2℃; humidity: ± 1% RH

4) Resolution: temperature: 1℃; Humidity: 1% RH

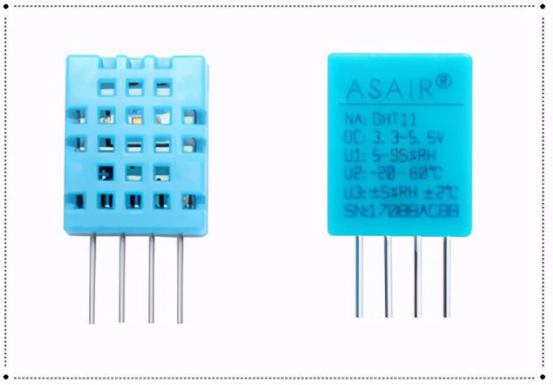

Figure 4 DHT 11 T&H sensor

(3) indicator

The display selected in this system is a 1602 liquid crystal display, as shown in Figure 5, which is a liquid crystal display module specialized for displaying characters such as numbers, symbols and letters. Produced by Shenzhen Chuanhang Electronic Technology Co., LTD., the model is CH1602A, the overall size is 80.0*36.0*12.0mm, the display area of characters is 64.5*16.0mm, the display character size is 3.50*3.60mm, the display mode is yellow black characters, the drive voltage is 5V.1602 LCD display is an industrial character type LCD display, up to can display 16 * 2=32 characters at the same time, light, high resolution, easy welding, more convenient to use.

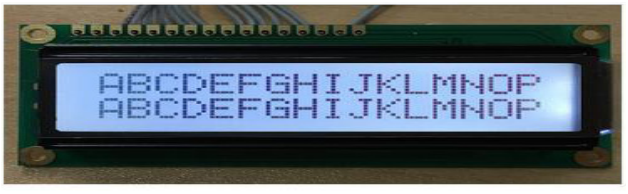

Figure 5 1602 liquid crystal display

(4) memorizer

The memory selected in this system is AT24C02 chip, as shown in Figure 6, which is a 1024-bit memory electric erasable chip produced by Ateml company. It adopts IIC bus technology, storage capacity of 2 kb, 256 bytes, divided into 32 pages, and has special write protection function.

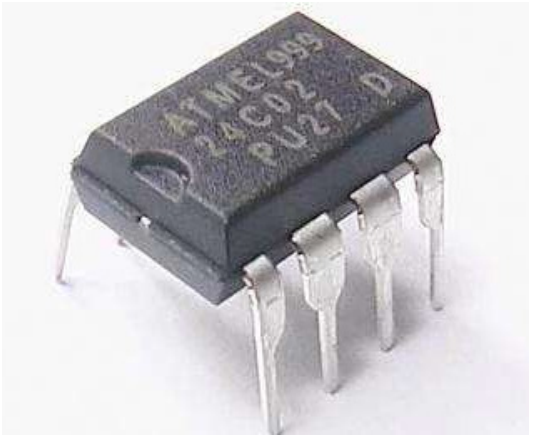

Figure 6 AT24C02 chip

(5)Alertor

This system selects the active electromagnetic buzzer, which is shown in Figure 7.

Figure 7 active electromagnetic buzzer

3.3.2 Circuit design of the data acquisition and display module

The hardware of the system data acquisition and display module includes DHT 11 T&H sensor and 1602 liquid crystal display.

The system collects the T&H in the machine room through DHT 11 T&H sensor. DHT 11 T&H sensor is a sensor with calibrated digital signal output, with a total of 4 pins. The schematic diagram of the circuit is shown in Figure 8.

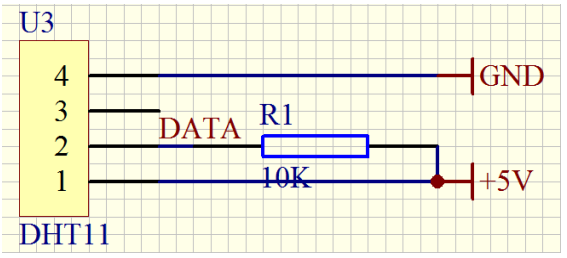

Figure 8 circuit diagram of DHT 11 T&H sensor

3.3.3 Threshold setting and the circuit design of the memory module

The system threshold setting, and memory module hardware consists of four independent keys and a AT24C02 chip.

The system sets the threshold through four keys, namely SET, ADD, SUB, and OK, connected with P2.0 foot, P2.1 foot, P2.2 foot and P2.3 foot of the MCU. Each key is independent, and each has a data input line. When the key closes, the corresponding I / O port of the MCU changes to low level, and the threshold value is changed by the change of high and low level of I / O port. The circuit schematic diagram is shown in Figure 9.

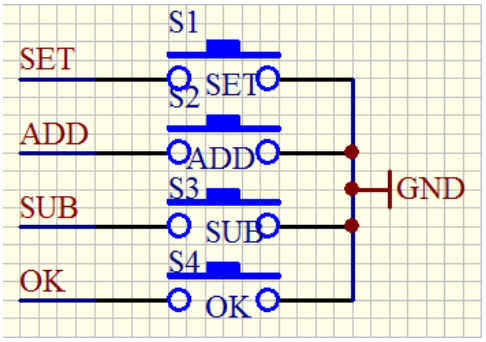

Figure 9 Key circuit diagram

The system stores the threshold data set by the AT24C02 chip and has 8 pins. The circuit diagram is shown in Figure 10.

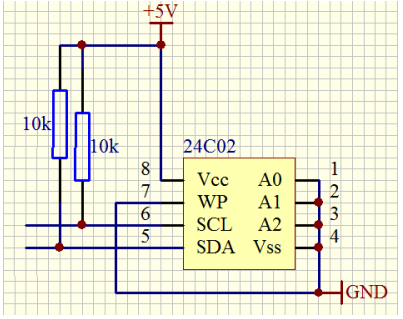

Figure 10 The circuit diagram of the AT24C02 chip

3.3.4 Circuit design of the T&H control module

The hardware of humidity temperature and temperature control module of the system includes alarm and relays.

The system uses the buzzer as the alarm, and the characteristics of PNP triode are used in the design. When the T&H value detected by the sensor exceeds the set threshold, the SU P3.5-foot output will change from high level to low level, making the triode turn on to control the operation of the buzzer. The system uses four relays to connect with P3.1~P3.4 feet of the MCU and drives the external equipment in the case of high temperature, low tempera-

ISSN 2959-6157

ture, high humidity and low humidity. When the T&H value detected by the T&H sensor exceeds the set threshold value, the corresponding pin output of the SU will change from high level to low level to make the triode turn on and engage the relay to drive the external equipment. The circuit diagram is shown in Figure 11.

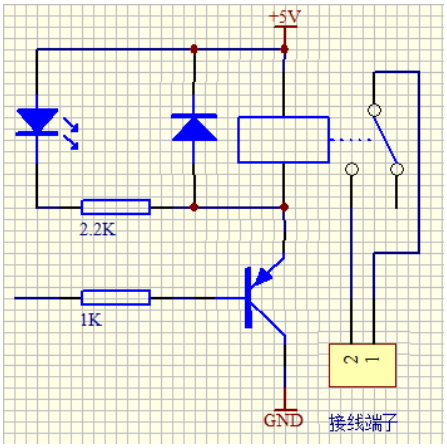

Figure 11 Relay circuit diagram

3.4 Software design

All the code of the system using C language writing, the software design of the system is a very important part of the design, the first need to design the flow chart of the whole system, the system is divided into several modules, and then implement the function of the module, finally integrate all the child module together, constitute the total system program. The master chart of the system is shown in Figure 12.

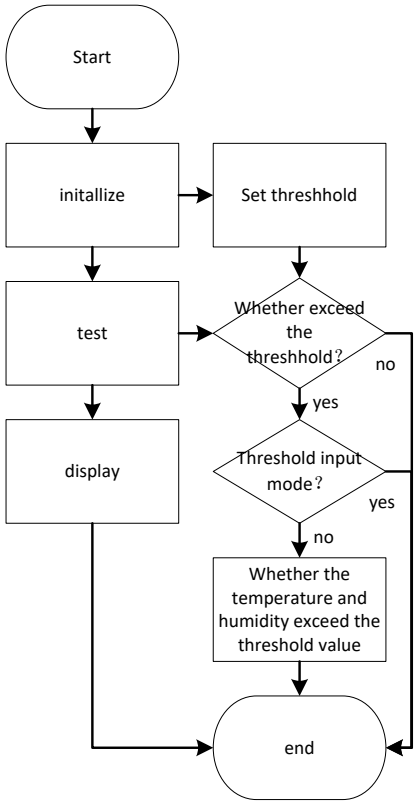

Figure 12 Flow chart of the main program

The function of the main program is to initialize the system, and then set the T&H threshold and store it in the AT24C02 memory chip, while the DHT 11 T&H sensor detects the T&H value of the current environment and displays it through the LCD1602. By comparing the detected T&H value with the set threshold value, judge whether the current T&H exceeds the set threshold value, not the alarm and the relay do not work, but the alarm is working in the non-threshold input state, the corresponding relay absorbs and drive the external equipment to work.

3.5 Functional test

When the hardware and software design of the system are completed, it is necessary to test the function of the system, query the errors in the design and modify them, and finally complete the design of the whole THCS. The physical diagram and circuit diagram of the THCS based on STC89C52 microcontroller are shown in Figure 13 and 14.

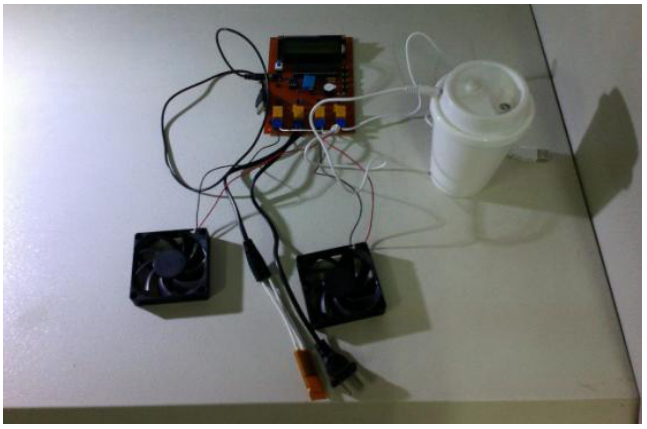

Figure 13 Physical diagram of the THCS

Figure 14 Circuit diagram of the system

Self-locking switch: When the switch is pressed, the switch closes and the power supply access circuit; when the switch plays, the switch is disconnected and the power supply is not connected to the circuit.

Power supply connection inlet: access to the 5V power supply.

Key: from top to bottom, the SET key, ADD key, SUB key and OK key. The T&H threshold can be set through the key.

3.5.1 System function test scheme

The T&H control function test of the system is divided into three situations, namely, system temperature control, system humidity control and system T&H control of the system.

When the temperature control of the test system, after turning on the switch to connect to the power supply, according to the T&H value of the current environment, set the threshold to keep the humidity value of the environment, and when the temperature value is above and below the set threshold, and observe the working situation of the indicator light and the external device in the two states.

When controlling the humidity control of the test system, after turning on the switch to access to the power supply, set the threshold value and set the threshold value according to the T&H value of the current environment, and observe the working situation of the indicator light and the external device in both states.

When the test system controls the T&H at the same time, set the threshold value according to the T&H value of the current environment, make the temperature value and the temperature value exceed the temperature value above but below the set humidity value but the humidity value exceeds the set threshold value and the humidity value below the set threshold value, and observe the working situation of the indicator light and the external device in each state.

3.5.2 System functional test and verification

1) Temperature control of the system

If the humidity value is within the set threshold range, first change the threshold value of temperature, the upper temperature limit 20℃ and the temperature lower limit 15℃, to make the temperature value of the environment exceed the set upper temperature limit, as shown in Figure 15.

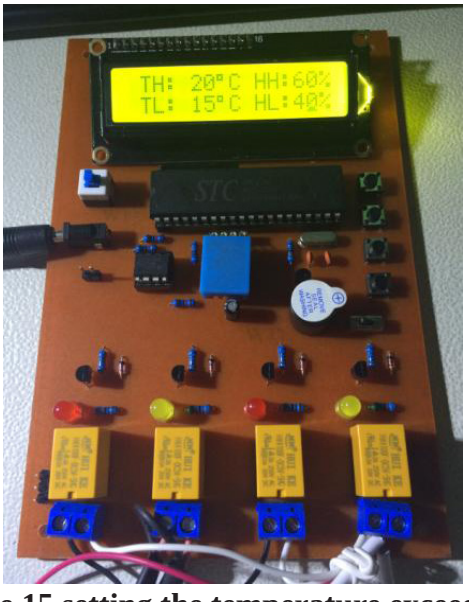

Figure 15 setting the temperature exceeds the upper limit

ISSN 2959-6157

The result indicator light (first from left) is lit, and the external device (fan) controlled by the cooling relay (first from left) is working, as shown in Figure 16.

Figure 16 Results diagram when the temperature exceeds the upper limit

Then change the threshold value of temperature, the upper temperature limit is 30℃, and the lower temperature limit is 25℃, so that the temperature value of the environment is lower than the set lower temperature limit.The result indicator light (second from left) is lit, and the external device (heating rod) controlled by the heating relay (second from left) is working, as shown in Figure 17.

Figure 17 Results diagram with temperature below the lower limit

2) Humidity control of the system

In the case that the temperature value is within the set threshold range,The upper humidity limit is 60% RH, and the lower humidity limit is 50% RH, so that the humidity value of the environment is lower than the set lower humidity limit, as shown in Figure 18.

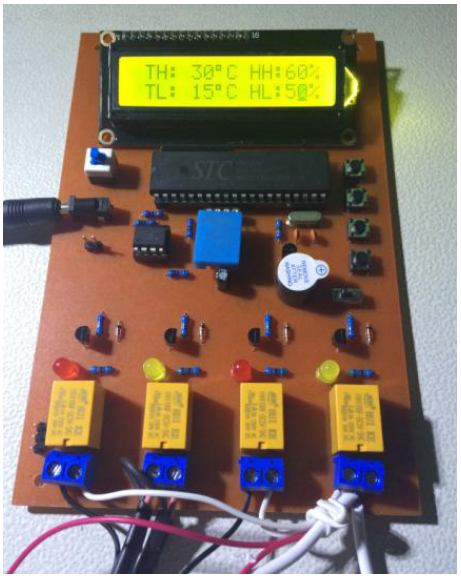

Figure 18 Threshold setting diagram when the humidity is below the lower limit

The result indicator light (from the fourth one on the left) is lit, and the external equipment (humidifier) controlled by the humidification relay (from the fourth one on the left) works, as shown in Figure 19.

Figure 19 Results diagram when the humidity is below the lower limit

3) Control the T&H of the system simultaneously

First, set the threshold of T&H, temperature limit 20℃, temperature limit 15℃, humidity limit 45% RH, humidity

limit 40% RH, so that the environment temperature value exceeds the set temperature limit and the humidity value of the environment also exceeds the set humidity limit, as shown in Figure 20.

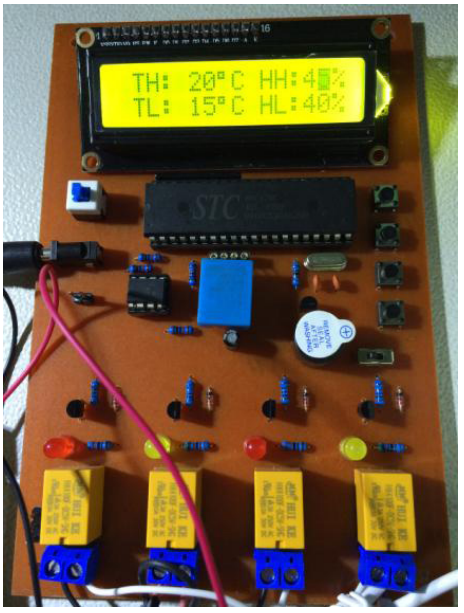

Figure 20 Threshold setting diagram when the temperature exceeds the upper limit and the humidity exceeds the upper limit

The result indicator light (the first and the third from the left) are on at the same time, and the cooling relay (the first from the left) and the dehumidification relay (the third from the left) start to work at the same time, as shown in Figure 21.

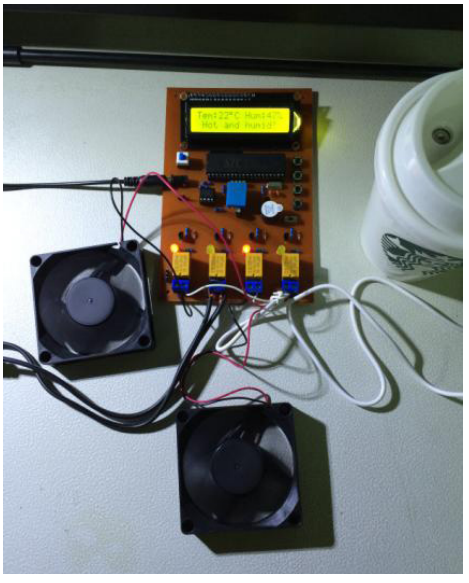

Figure 21 Results diagram when temperature exceeds the upper limit and humidity exceeds the upper limit

Through the above test and verification of the three functions of the system, the system can meet the requirements of displaying the T&H value in the room in real time and automatically controlling the T&H in the room according to the set T&H threshold.

4. CONCLUSION

The THCS generally meets the expected requirements, and the cost of the system is low. The system can mainly realize the following functions: 1) the actual detection and real-time display of T&H.2) Set the T&H threshold value manually.3) When the T&H exceeds the set threshold value, automatic alarm, the corresponding relay absorbs and drives the external equipment, and prompt the user through the small light. This design can effectively control the T&H in the switching room of the college to reduce the occurrence of switching aging and abnormal operation accidents caused by the T&H exceeding the predetermined value.

5. REVIEW

I think my research is successful since the functions of the device are realized favorably. I used SCM and sensors to achieve the perception, display and control of T&H. Although the current system is still a laboratory prototype, I believe my system will be used in practical scenarios in the future.

In addition to the system itself, I feel that what I have gained more is the experience in the process. I was a layman in the field of electronic design at the beginning. I learned a lot of experience through the EPQ program such as where to search for learning materials, how to make a time plan, how should I cope when I encounter difficulties and so on. After the systematic training in EPQ, I feel like I'm already getting started in electronics and I have also found some confidence in my learning ability.

In the next step, I will try to further improve my system, such as adding remote control function and remote alarm function. I really look forward to the day when my system will actually be used to solve practical problems.

REFERENCE

[1] Zhang, F. H., & Liu, X. C. (2007). Definition of temperature in thermodynamics. Journal of Hainan Normal University (Natural Science Edition), 20(02), 142-144.

[2] Mang, W. L., & Chen, F. Y. (1995). Measurement of temperature. Journal of Beijing University of Agriculture, (01), 99-103.

[3] Xu, J. Z., Zhao, L., & Feng, A. G. (2009). Humidity, dew point, and aridity. Electronic Mechanical Engineering, 25(05), 25-27+52.

ISSN 2959-6157

[4] Li, X. N. (2015). Development and application of single-chip microcomputer. Chinese and Foreign Entrepreneurs, (3Z), 171.
[5] Yin, X. Z., & De, X. Y. (2018). Analysis of the development and application of single-chip microcomputer technology. Southern Agricultural Machinery, 49(11), 146-146.
[6] Liu, T. Z. (2019). Discussion on the application and technology development of single-chip microcomputer in electronic technology. Electronic Paradise, (02), 21-21.
[7] Gong, Z. X., & Wu, Q. (2016). Examples of the application of single-chip microcomputers. Electronics World, (21), 89-90.
[8] An, Y., Li, H., & Yuan, Q. Q. (2022). Application of single-chip microcomputer technology in intelligent electronic products. Digital Technology and Application, 40(11), 25-27.
[9] Luo, X. (2024). The Application of SCM Technology in Electronic Engineering. Farm Machinery Using & Maintenance, (01),112-115.
[10] Han, K. (2015). Design and implementation of temperature and humidity detection and control instrument (Master's thesis). Jilin University. Supervisor: Huang, Y. P.
[11] Jia, L., Zhang, X. P., Tian, X. D., & Wu, J. F. (2011). Research progress of key equipment for independent temperature and humidity control air conditioning system. Fluid Machinery, 39(04), 67-70.
[12] Tong, L., Yang, Y. F., & Zhang, B. H. (2006). Composition and development of intelligent temperature and humidity monitoring system. Journal of Agricultural Mechanization Research, 28(05), 39-41.
[13] Zhang, Y. W. (2011). Design and implementation of intelligent temperature and humidity controller based on STC single-chip microcomputer. Hebei University of Technology, 1-4.
[14] Li, Z. W. (2013). Design of indoor temperature and humidity automatic control system based on nebulizer. Hefei University of Technology, 1-2.
[15] Zhang, D. L., Li, X., Dai, M., & Quan, L. W. (2010). Design of low-cost automatic temperature and humidity control system for silkworm room based on DHT11. Modern Agricultural Science and Technology, (18), 14-15.
[16] Wu, S. C. (2012). Thoughts and exploration on energy-saving effect of independent temperature and humidity control air conditioning system. Urban Construction Theory Research, (4), 14.
[17] Yang, D., & Bao, J. Y. (2013). Application and development trend of sensors and measuring instruments. Weights and Measures, (7), 13-15.
[18] Xiao, J. T. (2019). Realization of intelligent temperature and humidity monitoring system. Electronic Technology and Software Engineering, (17), 74-75.
[19] Barik, & Lalbihari. (2019). IoT based temperature and humidity controlling using Arduino and Raspberry Pi. INTERNATIONAL JOURNAL OF ADVANCED COMPUTER SCIENCE AND APPLICATIONS, 10(09), 494-502.
[20] Karra, A., Kondi, B., & Jayaraman, R. (2020). Implementation of wireless communication to transfer temperature and humidity monitoring data using Arduino Uno. International Conference on Communications and Signal Processing, 1101-1105.