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Design and implementation of basement air conditioning system based on The Internet of Things

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ABSTRACT:

With the rapid development of modern urban construction, the utilization rate of ground space needs to be improved urgently, and the construction of basements has also reached its peak. Due to the basement is easy to wet water ingress. In order to control the temperature and humidity of the basement, the early warning of flood disaster in the basement, the disinfection of ultraviolet lamps, and the solution to the problem of humid water inflow in the basement, the basement air conditioning system was designed. The system can open the fan for mechanical ventilation when the indoor humidity is greater than the outdoor humidity, detect whether the indoor water is entering, if the water buzzer has an alarm, open the ultraviolet light for disinfection and sterilization when there is no one in the basement, improve the air condition, and display data on the cloud platform and mobile app.

Keywords: Single-chip microcomputer, temperature and humidity, basement, air conditioning, One Net cloud platform

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1. INTRODUCTION

With the rapid development of urbanization, cities are becoming more crowded. Qian Qihu, an academician of the Chinese Academy of Engineering, once proposed that the effective solution to the increasing congestion of urban traffic is to develop underground space, and at the same time avoid the situation of 'zip-chain highway', but unfortunately, the underground space in many areas of China has not been used [1]. Then Chinese cities began to develop underground space on a large scale. Because the basement is lower than the outdoor ground level, infiltrated by water in the soil and groundwater [2], when the temperature in the basement is lower than 23 °C and the relative humidity exceeds 70% RH, there will be a very serious condensation phenomenon, and when the relative humidity of the basement is too high, the building wall will cause mildew due to long-term wetness [3], causing damage to the wall and affecting the internal environment of the basement.

In order to solve the problem of humid water in the basement, the basement air conditioning system is designed, the system uses sensors to monitor the temperature and humidity of the basement in real time, and select whether to turn on the fan or dehumidifier to reduce the indoor humidity by comparing the indoor and outdoor temperature and humidity. If the basement is flooded, the alarm is timely alarmed by the alarm to avoid problems in the basement. The human infrared sensor is used to detect whether there is anyone in the basement and determine whether to turn on the ultraviolet lamp for light disinfection.

2. OVERALL SYSTEM SCHEME DESIGN

The basement air conditioning system is based on the STC15F2K60S2 microcontroller design. Using two temperature and humidity sensors to measure the data, the data is transmitted to the microcontroller, and the indoor humidity is selected to reduce the indoor humidity by comparing the indoor and outdoor temperature and humidity levels. Use a water level sensor to determine whether water is entering the basement, and the buzzer alarms the water entering. Human infrared sensors determine whether there are people in the basement, and when there is no one, turn on ultraviolet rays for sterilization and disinfection to improve air quality. Finally, the WIFI module is used to upload the measurement data to the cloud platform, and the mobile APP displays the basement air parameters. The block diagram of the basement air conditioning system is shown in Figure 1.

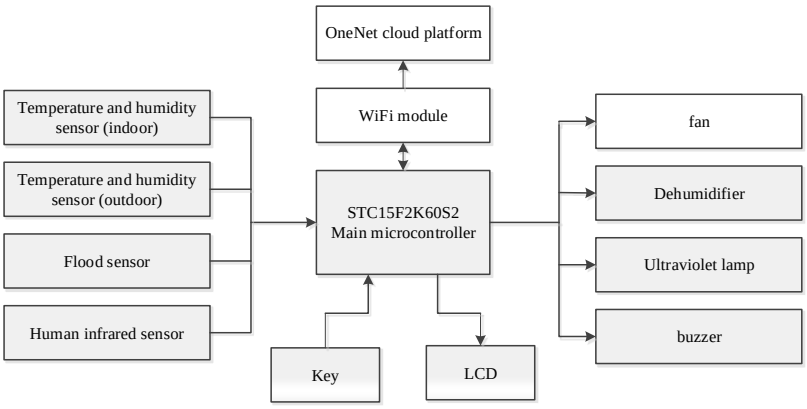

Fig. 1 Overall block diagram of the system

3. HARDWARE CIRCUIT DESIGN AND IMPLEMENTATION

The hardware circuit design in this system is divided into three parts: control unit design, sensor circuit design and alarm circuit design.

1 Control unit design and implementation

The core processor of the air conditioning system adopts STC15F2K60S2 single- chip microcomputer. The main task is to control the underground room temperature and humidity data of the sensor, control the LCD display to display the indoor and outdoor temperature and humidity, and realize the control of the peripheral module circuit. The 18th V CC pin of the microcontroller is connected to the power supply, and the 20th G ND pin is grounded. The schematic diagram of the single-chip microcomputer circuit is shown in Figure 2.

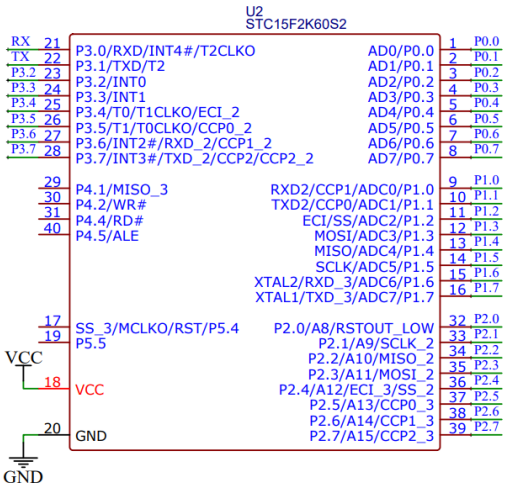

Figure 2 STC15F2K60S2 MCU circuit schematic

2 Sensor circuit design and implementation

The sensor design part mainly uses temperature and humidity sensors, water level sensors, and human infrared sensors. The sensor functions are described in detail below.

(1) Temperature and humidity sensor

This design uses two DHT11 temperature and humidity sensors to obtain the temperature and humidity inside and outside the basement. The temperature and humidity sensors are shown in Figure 3. By judging the indoor and outdoor temperature and humidity conditions, the working status of the fan and dehumidifier is controlled. When the indoor humidity in the basement is higher than the outdoor humidity, it will alarm and turn on the fan. When the indoor and outdoor humidity is higher than 60 % RH, mechanical ventilation is meaningless. The system turns off the fan and turns on the dehumidifier to reduce the indoor humidity. Through these measures, the humidity in the basement is controlled between 30 % RH and 60 % RH.

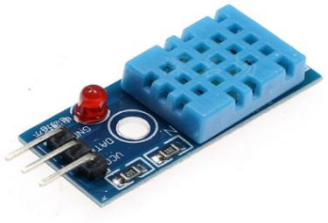

Fig. 3 Temperature and humidity sensor

Figure 4 shows the pins and wiring information of the temperature and humidity sensor. The sensor has three pins, which are divided into V CC, I /O, and GND. The No. 1 pin V CC is connected to the power supply, the No. 2 pin is connected to the P3.6 pin of the STC15F2K60S2 microcontroller, and the No. 3 pin G ND is grounded.

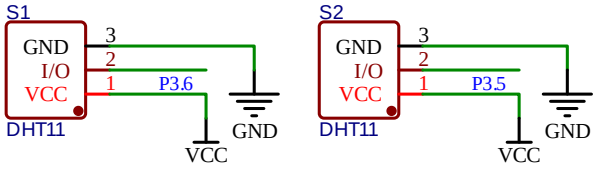

Figure 4 Schematic diagram of the temperature and humidity sensor circuit

(2) Water level sensor

Since the system needs to detect the water inflow in the basement, the water level sensor is used for detection, and the alarm function is activated when the water enters, so as to avoid a series of potential safety hazards caused by the water inflow in the basement. When there is water in contact with the parallel wire, the module outputs a high-level signal and the buzzer alarms; when there is no water in contact with the parallel wire, it outputs a low-level signal and the buzzer turns off. The water level sensor is shown in Figure 5.

Figure 5 Water level sensor

The water level sensor has three pins S, VCC and GND, among which the V CC pin is connected to the power supply, the GND pin is grounded, and the S pin is connected to the STC15F2K60S2 single - chip microcomputer P1.6 pin. The circuit schematic diagram of the water level sensor is shown in Figure 6.

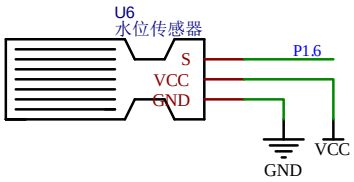

Figure 6 Water level sensor pin information

(3) Human infrared sensor

The local basement air-conditioning system uses ultraviolet lamps for disinfection and sterilization, but because ultraviolet rays will cause adverse consequences to the human body for a long time, the human infrared sensor is used to determine whether there are people in the basement, and the ultraviolet lamps are turned on for indoor disinfection when no one is there to prevent the basement from becoming wet. Bacteria, poor air quality. UV lights are turned off when someone is in the basement. The HC-SR501 human body infrared sensor is shown in Figure 7.

Figure 7 Human infrared sensor

The human body infrared sensor is divided into three pins, the No. 1 pin is connected to the power supply VCC, the No. 2 pin is connected to the P 1.4 pin of the microcontroller, and the No. 3 pin is grounded. The schematic diagram of the human body sensing module circuit is shown in Figure 8.

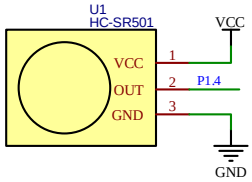

Figure 8 Circuit schematic diagram of human body sensing module

3 Design and implementation of alarm circuit

In the air conditioning system, when the water level sensor detects that there is water, the buzzer alarms. When the indoor humidity is greater than the outdoor humidity, the buzzer alarms. Through the alarm, the staff can respond in time to avoid losses. The schematic diagram of the alarm circuit is shown in Figure 9.

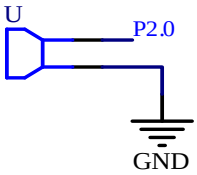

Figure 9 Alarm circuit

4. SOFTWARE DESIGN AND IMPLEMENTATION

This system mainly uses C language to write in Keil uVision4 software, realizes the initialization of STC15F2K60S2 single-chip microcomputer program, processes the underground room temperature and humidity data collected by the sensor, and adjusts the basement air by controlling the temperature and humidity. Upload the data to the cloud platform and display the data through the One Net cloud platform and mobile APP.
1 System main program design
The main program initializes the MCU program, controls the sensor to collect air data in the basement, then sends the collected temperature and humidity data to the STC15F2K60S2 MCU for data processing, controls the working status of the fan, dehumidifier, ultraviolet lamp and buzzer, and then connects to the One Net cloud platform, real-time monitoring of indoor and outdoor temperature and humidity changes, to achieve the effect of air conditioning in the basement. The program flow chart is shown in Figure 10.

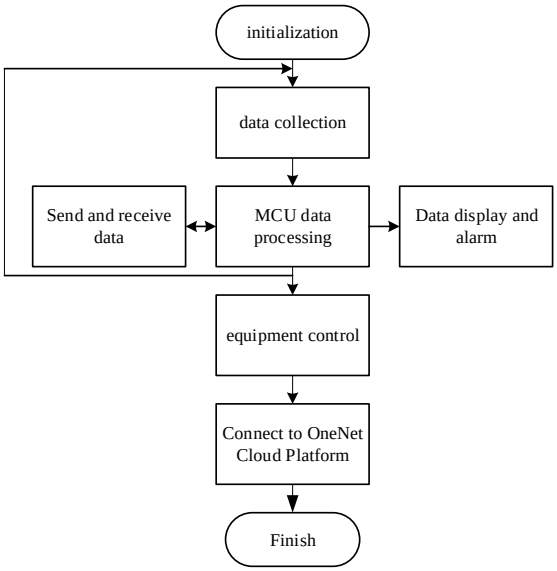

Figure 10 Main program flow chart

2 Main subprogram design

The main subprograms of the system are mainly divided into four parts: temperature and humidity acquisition program, display screen program, button program and WIFI program.
(1) Temperature and humidity acquisition program design
This program detects the indoor and outdoor temperature and humidity of the basement for the temperature and humidity sensor. After the D HT11 is powered on, the single-chip microcomputer sends a start signal, the cluster computer sends a response signal, the bus is pulled up by a pull-up resistor, and the host delays 20 μs. The host is set as input to judge whether the response signal of the slave has a low-level response signal. If it does not respond, it will jump out, and if it responds, it will run downward, and then enter the data receiving state to receive the collected underground room temperature and humidity data and perform data verification. The program flow chart is shown in Figure 11.

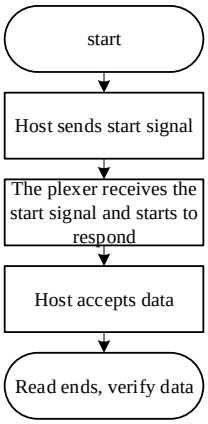

Figure 11 Flow chart of temperature and humidity collection procedure

(2) Display screen programming

In order to better understand the air parameters of the basement, the system uses an LCD display screen to display the indoor and outdoor temperature and humidity of the basement, so that the staff can more intuitively observe the temperature and humidity changes. First initialize the display screen, the LCD display screen performs the screen-clearing operation, the character string is sent by the single-chip microcomputer, and the underground room temperature and humidity data are displayed on the LCD 1602. The flow chart of the display program design is shown in Figure 12.

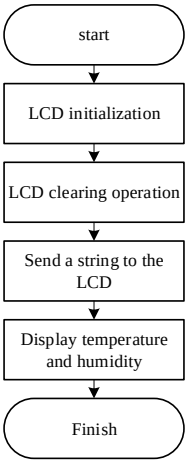

Figure 12 Display screen program flow chart

(3) Button programming

This design is to better control the working status of fans, buzzers, dehumidifiers, and ultraviolet lamps. Four buttons are used to control these four devices, so that the staff can change the working status of the devices at any time. Determine whether a key is pressed, then determine which key is pressed, and execute the key design program. The flow chart of the button program is shown in Figure 13.

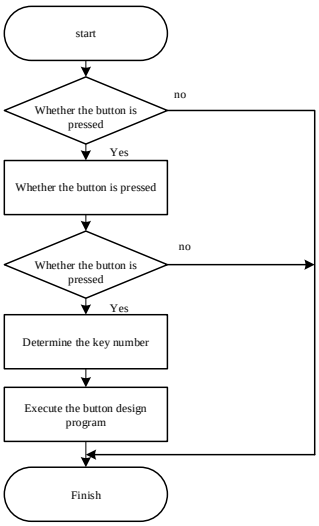

Figure 13 Button program flow chart

(4) WIFI programming

In order to enable the staff to observe the underground room temperature and humidity at any time, the local basement air conditioning system uses a WIFI module to connect to the cloud platform, and updates the detection data in real time on the cloud platform and mobile APP. Using the M QTT protocol, it is connected to the One Net cloud platform. First connect the device ID, send bytes and strings, judge the connection status and connect to One Net, then report the data to the cloud platform, accept the AT command service, and the serial port receives the interrupt function and receives the data. The WIFI module program flow chart is shown in Figure 14.

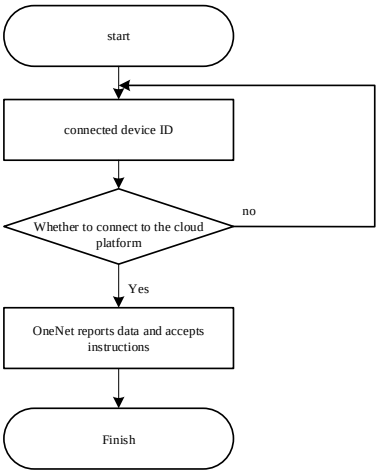

Figure 14 WIFI program flow chart

3 Design and Implementation of OneNet Cloud Platform

This system uses the One Net cloud platform as a data center to upload and download data. The following describes the design on the cloud platform. First, add equipment to the cloud platform for later data transfer, select multi-protocol access, data visualization, and create the device ID is 906891119, the product ID is 494488, its API Key is 20220314.

5. SYSTEM TEST

1 Data collection test results and analysis
This design is a basement air conditioning system, the sensor detects the data, and controls the work of the fan, dehumidifier, ultraviolet lamp and buzzer through the single chip microcomputer. After testing, the sensors can work normally, and the system has realized the expected functions. The testing results are shown in Table 1.

Table 1 Sensor test results

Test Equipment	data name	Test Results	Does it meet expectations
Indoor temperature and humidity sensor	temperature	24℃	Yes
	humidity	35%RH	Yes
Outdoor temperature and humidity sensor	temperature	27℃	Yes
	humidity	37%RH	Yes
Water level sensor	high level	have water	Yes
	low level	Anhydrous	Yes
Human infrared sensor	high voltage	someone	Yes
	low voltage	unmanned	Yes

After testing, the fans, dehumidifiers, ultraviolet lamps, and buzzers in this system can work normally. The testing results are shown in Table 2.

Table 2 Test results of devices such as fans

Test Equipment	Test Conditions	Test Results	Does it meet expectations
fan	Indoor humidity is higher than outdoor humidity	Open	Yes
	Indoor humidity is lower than outdoor humidity	Close	Yes
dehumidifier	The indoor and outdoor humidity is greater than 60%RH, and the fan is turned off	Open	Yes
	Indoor and outdoor humidity is less than 60%RH	Close	Yes
ultra violet	Human infrared sensor detects no one	Open	Yes

light	Human infrared sensor detects people	Close	Yes
buzzer	The indoor humidity is greater than the outdoor humidity, and the water level sensor detects water ingress	Open	Yes
	The indoor humidity is lower than the outdoor humidity, and the water level sensor detects that no water has entered	Close	Yes

2 Cloud platform test and result analysis

The cloud platform detection data interface is shown in Figure 15. The indoor temperature is 24 ℃, the outdoor temperature is 24 ℃, the indoor humidity is 34 % RH , the outdoor humidity is 36 % RH , and the buzzer is off.

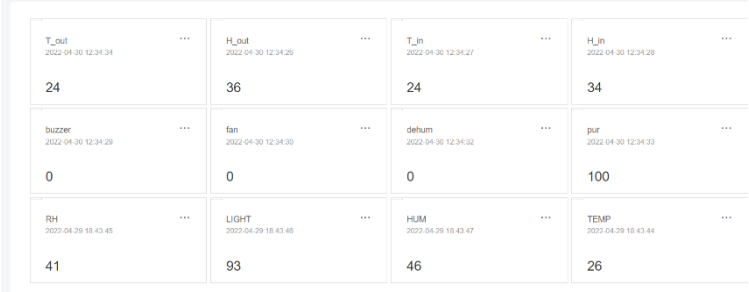

Figure 15 Cloud platform detection data

Software testing mainly tests whether the programming can be compiled successfully, whether there are bugs, whether the data can be uploaded to the One Net cloud platform correctly, whether the display is correct, and whether the data can be successfully displayed on the mobile APP. Data is the source of data flow on the cloud platform. After testing, the data on the cloud platform can be displayed normally, and the test results are shown in Table 3.

Table 3 Cloud platform data flow test results

Cloud platform data stream ID	test display	Test Results
T_out	2 6	works fine
T_in	2 6	works fine
H_out	2 7	works fine
H_in	2 9	works fine

3 Mobile phone APP effect test

mobile phone APP is designed so that users can more conveniently and quickly know the current indoor and outdoor temperature and humidity changes, as well as the working status of fans, buzzers, dehumidifiers, and ultraviolet lamps. The mobile phone APP interface is displayed as shown in Figure 16. The indoor temperature is 26 ° C, the outdoor temperature is 26 ° C, the indoor humidity is 75 % RH , and the outdoor humidity is 63 % RH . Since the indoor and outdoor humidity is greater than 60 % RH, the fan is turned off and dehumidified. The machine is on and the buzzer is on. After testing, the mobile phone APP can detect data changes in real time.

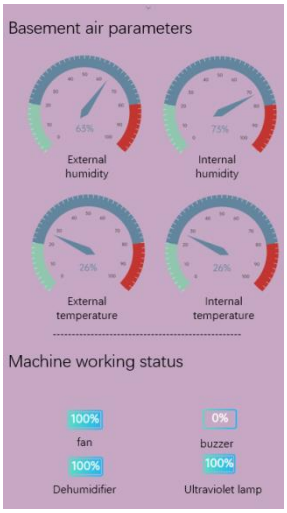

Figure 16 Mobile APP interface display

6. CONCLUSION

In this paper, by analyzing the development process and status quo of the current basement air conditioning system, a basement air conditioning system with STC15F2K60S2 microcontroller as the main control is designed. Two DHT11 temperature and humidity sensors are used to collect the indoor and outdoor temperature and humidity of the basement, and then display it in real time through the LCD1602 display screen. Underground room temperature humidity. When the indoor humidity is higher than the outdoor humidity, the alarm will be started and the fan will be turned on. When the indoor and outdoor humidity are both higher than 60%RH, the fan will be turned off and the dehumidifier will be turned on. HC-SR501 human body infrared sensor part, when someone enters the basement, the sensor will detect someone, at this time the ultraviolet light is turned off, and the ultraviolet light is turned on when there is no one, the water level sensor detects whether the basement is flooded, and the water intake buzzer alarms. Finally, through the MQTT protocol, it is connected to the One Net cloud platform with WIFI, and the data can also be displayed on the mobile APP, which realizes the real-time monitoring of the temperature and humidity inside and outside the basement and improves the air quality.

After testing, the system achieves the expected function, can accurately control the working status of the fan, buzzer, dehumidifier and ultraviolet lamp, and realizes the air conditioning of the basement.

7. REFRENCES

[1]. Longrong Cui. [2015] "Research on land reserve in the new urbanization of Nanxi District" Southwest Jiaotong University.
[2]. Zhongquan Lin. [2018] "Analysis of water leakage in Jinjiang Yujing basement and its control measures" Fujian Architecture, Issue05: pp. 65-68.
[3]. Xuanzhi Wang. [2021] "Analysis on the Application of Vegetable Planting Technology in Smart Greenhouse Based on Internet of Things Technology" Agricultural Engineering Technology Vol.41, Issue36: pp. 55-56.
[4]. Pengfei Ma. [2021] "Research on ventilation simulation and dehumidification of underground garages in cold regions" North China University of Technology.
[5]. Xiuli Yang. [2018] "Research on the current situation and improvement of indoor temperature and humidity changes in underground garages——Taking an underground garage in a community on Anda Road, Qingdao as an example" Ju She Issue28: pp. 182.
[6]. Haixia Wen. [2019] "Discussion on condensation and dehumidification of underground garages in coastal areas" Sichuan Cement, Issue04: pp. 328.
[7]. XUE FF, XUC, SHEN WZ, et al. [2020] "Ventilation in pumped storage power stations: Influence of dehumidifiers in an underground tunnel" Applied Thermal Engineering Issue172: pp. 115-162.
[8]. Yuhong Zheng, Yanhong Yan. [2021] "Design of Ambient Temperature, Humidity and PM2.5 Concentration Monitor Based on Microcontroller" Computer Knowledge and Technology Vol.17, Issue32: pp.104-106.
[9]. Peichang Chen, Yu'e Zhao. [2021] "Research on the cultivation mode of watermelon in smart greenhouse based on Internet of things technology" Modern Agricultural Machinery Issue04: pp. 110-112.
[10]. Jianhui Huang. [2021] "Design of temperature and humidity control system for traditional Chinese medicine cabinet based on single chip microcomputer" Electronic Manufacturing Issue15: pp. 87.
[11]. Jing Ren. [2021] "Design of temperature and humidity measurement system based on STM32 microcontroller" Intelligent IoT Technology Vol.4 Issue04: pp. 16-21+39.
[12]. Siyang Zhang. [2021] "Analysis and Planning Research on the Development and Utilization of Underground Space in Xichang City" Journal of Xichang University (Natural Science Edition) Vol.35, Issue02: pp. 63-67.
[13]. Binzhe Sun. [2021] "Development of underground dehumidification system based on Internet of Things technology" Dalian University of Technology.

[14]. Shouguo Gu. [2021] "Research on the waterproof and drainage system of residential underground roof" Yanshan University.
[15]. Haicheng Nan, Yayuan Tang, et al. [2021] "Temperature and humidity pm2.5 detector based on single-chip microcomputer" Computer Knowledge and Technology Vol.17, Issue08: pp. 208-209+222.
[16]. Pai Peng. [2021] "Research on Wi-Fi mobile phone monitoring of temperature and humidity in substations based on single chip microcomputer" Rural Electrification Issue01: pp.58-59.
[17]. Xiaobing Lv. [2020] "Design of temperature and humidity meter based on STC15 microcontroller" Shanxi Electronic Technology Issue06: pp. 14-16+28.
[18]. Fangli Miao, Zhihui Yao. [2020] "Analysis on the waterproof construction technology of basement in construction engineering" Jiangxi Building Materials Issue10: pp. 140-141.
[19]. Danyan Ni. [2020] "Design and implementation of temperature and humidity environment monitoring system based on STC89C52 microcontroller" Industrial Science and Technology Innovation Vol.2, Issue19: pp. 43-44.
[20]. Shouhuan Luo. [2020] "Design of greenhouse temperature and humidity controller based on single chip microcomputer" Digital Communication World Issue02: pp. 195.
[21]. Ziliang Wang. [2019] "Design and research of temperature and humidity monitoring system based on single chip microcomputer" Modern Salt Chemical IndustryVol.46, Issue06: pp. 72-73.
[22]. Haokai Ma. [2019] "Monitoring system of temperature and humidity based on single chip microcomputer" Electronic World Issue03: pp. 151-152.
[23]. Yuxin Fang. [2012] "Research and application of temperature and humidity control system based on single chip microcomputer" Harbin Engineering University.
[24]. Xiaoge Li, Na Li. [2022] "Design of Temperature and Humidity Monitoring System for Tobacco Seedling Greenhouse Based on Single Chip Computer" Southern Agricultural Machinery Vol.53, Issue04: pp. 30-33+37.