International Core Journal of Engineering Volume 6 Issue 11, 2020
ISSN: 2414-1895 DOI: 10.6919/ICJE.202011_6(11).0034

Design of Air Quality Monitoring System Based on Microcontroller

Wei Wang, Xin Tian, Li Wang

Department of Electronic Engineering, Xi'an Aeronautical University, Xi'an Shaanxi 710077, China.

Abstract

The study of a system that can monitor air quality parameters in real time has practical significance for improving air quality and improving people's home environment. This article designs an air quality monitoring system based on a microcontroller, including STC89C52 microcontroller, temperature and humidity sensor, PM2.5 sensor, A/D0832 modulus, liquid crystal display, buzzer, etc. Use sensors to collect surrounding environmental data, display the real-time collected environmental data on the LCD display, and connect an external buzzer alarm module to buzzer when the preset temperature, humidity and haze concentration are exceeded. Hardware and software simulation tests are carried out on the overall monitoring system designed, and the results show that the overall system circuit is operating normally and the test data meets the design requirements.

Keywords

Microcontroller; Temperature and Humidity Sensor; PM2.5 Sensor; Buzzer Alarm.

1. Introduction

With the rapid development of my country's social economy, air pollution is a serious threat to people's health. If you can use environmental monitoring equipment to monitor indoor air conditions in real time and remind people to make adjustments, you can better improve indoor air quality [1]-[4].

This paper designs an indoor air quality monitoring system based on microcontroller. This system can quantify the tiny particles, temperature and humidity in the air state and display them in digital form, allowing people to clearly grasp the current environmental data. If the monitoring data exceeds the optimal interval of people's preset data, it can also provide real-time alarms to prompt people to take measures to adjust air quality.

2. System Overall Design

2.1 Design Content

This subject is an indoor air quality monitoring system designed based on a single chip microcomputer, with a single chip microcomputer as the core controller [5] [6], composed of PM2.5 sensor module, analog-to-digital converter module, temperature and humidity sensor module, liquid crystal display module, buzzer alarm module and buttons constitute. The main design content is as follows,

(1) Use dust sensor and temperature and humidity sensor to collect air quality parameters.

(2) Use an analog-to-digital converter to convert data from analog signals to digital signals.

(3) A microcontroller is used as the control core to calculate the concentration of dust and temperature and humidity in the air.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202011_6(11).0034

(4) The liquid crystal display module is used as a display screen to display all measured values.

(5) Use the button to set the warning interval value. When the measured real-time environmental value exceeds the warning interval value, the buzzer will sound to remind.

2.2 Design Program

This system is mainly composed of five parts: data collection module, data processing, buzzer module, display module, and analog-to-digital conversion module. The external button control circuit is connected. When the system is running, the temperature and humidity sensor and PM2.5 sensor collect current environmental data in real time, and then transmit the data to the A/D analog-to-digital converter, convert the original analog signal into a digital signal, and then transmit it to the single-chip control system. Then the microcontroller control system compares the current data with the preset data. If the preset data interval is exceeded, the microcontroller controls the buzzer model to make the module send out an alarm signal and transmit the data to the LCD display. The overall block diagram of the system is shown in Figure 1.

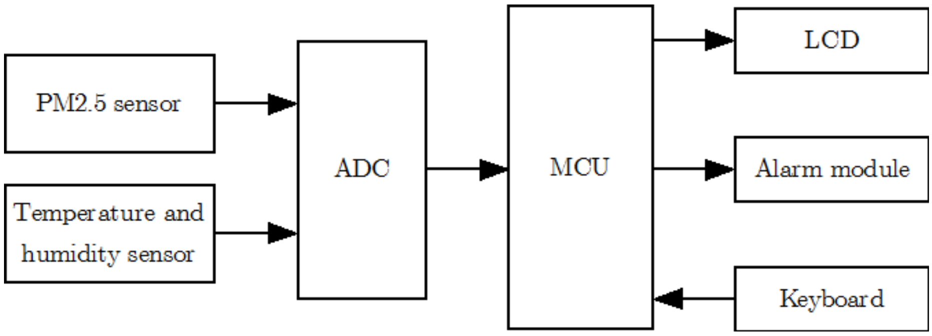

Figure 1. Overall block diagram of the system.

3. Hardware Design

3.1 Main Control Circuit

Based on the design requirements, the circuit schematic diagram of this system consists of a microcontroller, A/D conversion module, liquid crystal display module, buzzer alarm module, power circuit module, temperature and humidity sensor module, PM2.5 sensor module, and program download circuit and button module composition. The system schematic diagram is shown as in Figure 2.

3.1.1 The smallest microcontroller system

The minimum system of the single-chip microcomputer is composed of input and output equipment, power supply, clock circuit, and reset circuit. The reset circuit is to initialize the single-chip microcomputer, the clock circuit provides the timing for the single-chip microcomputer, and the power supply is a DC stabilized power supply, as shown in Figure 3.

3.1.2 Reset circuit

Before the microcontroller is powered on, the system needs to be reset, that is, the microcontroller is initialized. The CPU and the rest of the device are in the initial state and work in this state. Since the microcontroller itself cannot be initialized automatically, it must be equipped with a corresponding initialization circuit, also called a reset circuit. The reset method of the one-chip computer includes power-on reset and button reset. What this design uses is the button reset, as shown in Figure 4.

3.1.3 Crystal oscillator circuit

The clock circuit can be used as an oscillator to provide the clock rhythm for the microcontroller, as shown in Figure 5. The clock mode of the single-chip microcomputer is composed of an oscillation circuit and a clock circuit. There are two ways to generate a clock: internal clock and external clock. This design uses the internal clock method.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202011_6(11).0034

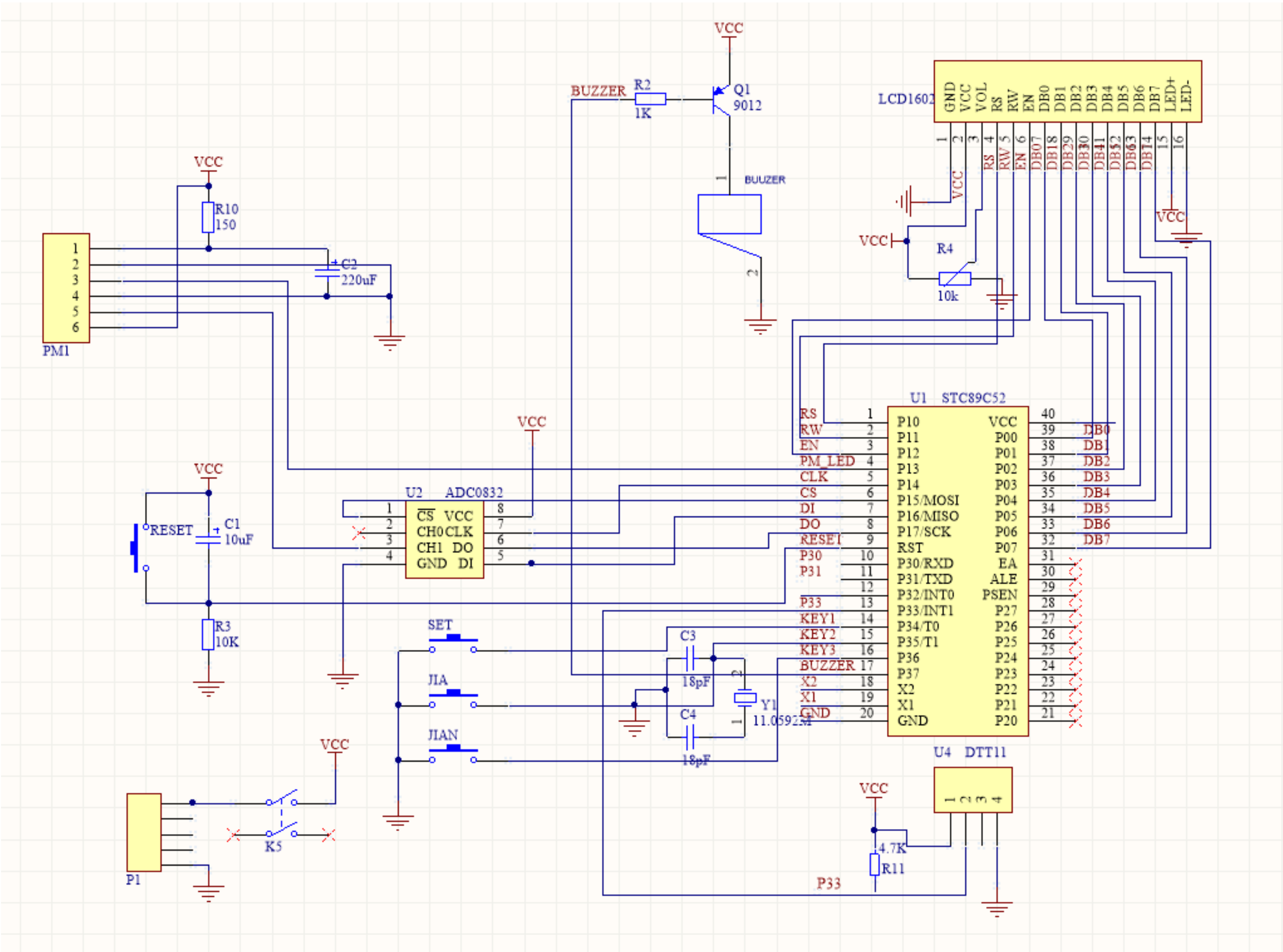

Figure 2. System schematic diagram.

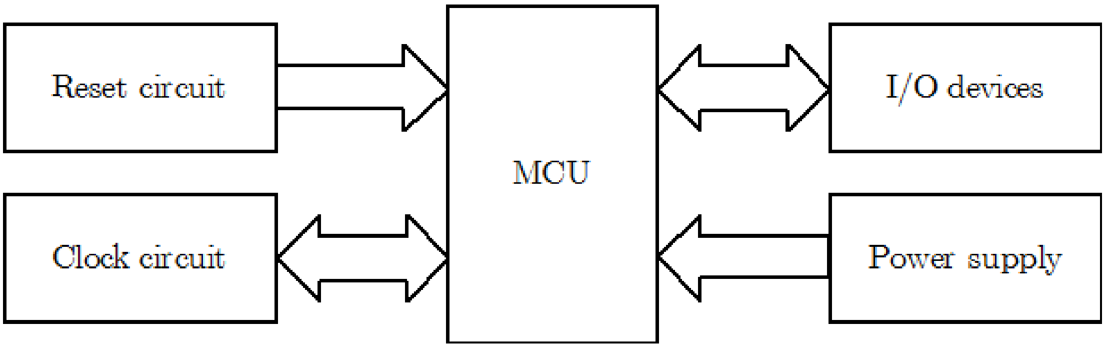

Figure 3. The smallest microcontroller system.

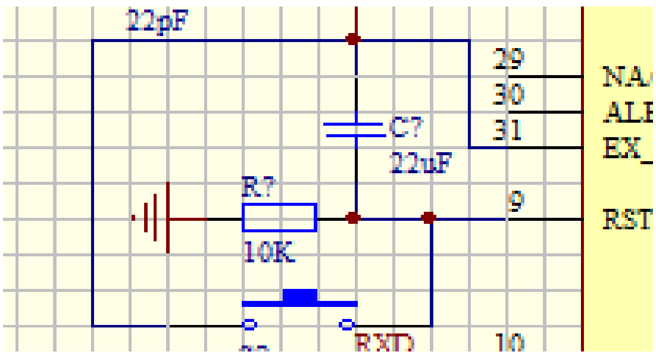

Figure 4. Reset circuit.

ISSN: 2414-1895
DOI: 10.6919/ICJE.202011_6(11).0034

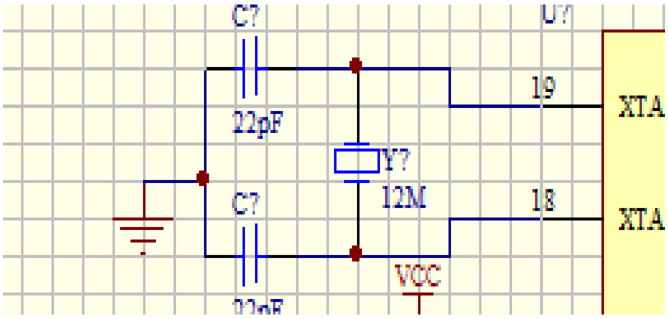

Figure 5. Schematic diagram of crystal oscillator circuit.

3.2 Temperature and humidity sensor module

DHT11 is a modern new temperature and humidity sensor [7] [8], and its working parameters are shown in Table 1.

Table 1. Working parameters of temperature and humidity sensor.

Parameter name	Parameters
Supply voltage	3.3-5.0V DC
Working current (average)	0.3mA
Sampling period	≥2S
Measuring range	Temperature: 0-50°C, humidity:20-95% RH
Measurement accuracy	Temperature:±2°C , humidity:±5% RH
Resolution	Temperature: 1°C, humidity: 1% RH
Output signal	Single bus digital signal

The workflow of DHT11 is,

(1) The microcontroller sends a detection signal to the sensor, and the sensor responds with a signal.

(2) The microcontroller receives the signal and is ready to receive data.

(3) Start to receive data (receive 40 bits at a time).

After the microcontroller sends out a signal, the sensor turns from static to working mode. After the microcontroller start signal ends, DHT11 sends out a detection signal, sends 40bit data, and performs a signal acquisition.

3.3 Dust sensor module

The sensor used in this system is Sharp's GP2Y1010AU [9], and its advantages are as follows.

(1) The sensor can detect the dust concentration in the air, with high accuracy and strong consistency.

(2) The sensor can adjust the data by itself. When there are tiny particles attached to the surface of the sensor, the system will automatically calibrate the concentration parameters to ensure the accuracy of the measurement data.

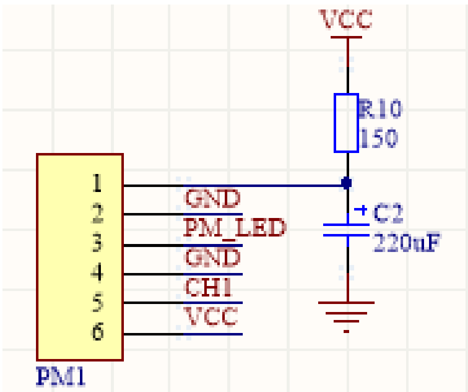

Figure 6. Circuit design diagram of PM2.5 sensor.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202011_6(11).0034

According to the description in the user manual of the dust sensor, its pin functions are: first pin: 5V working voltage input terminal, second pin: serial data output, third pin: serial data input, fourth pin: dust Concentration analog voltage output, the fifth pin: floating, the sixth pin: connected to the working voltage. The circuit design of the dust sensor is shown in Figure 6.

3.4 Analog to digital conversion module

The main function of the A/D conversion chip is to receive the analog signal sent by the sensor and convert the analog signal into a digital signal. The LCD screen will display the digital signal after receiving the digital signal. A/D circuit schematic diagram is shown as in Figure 7.

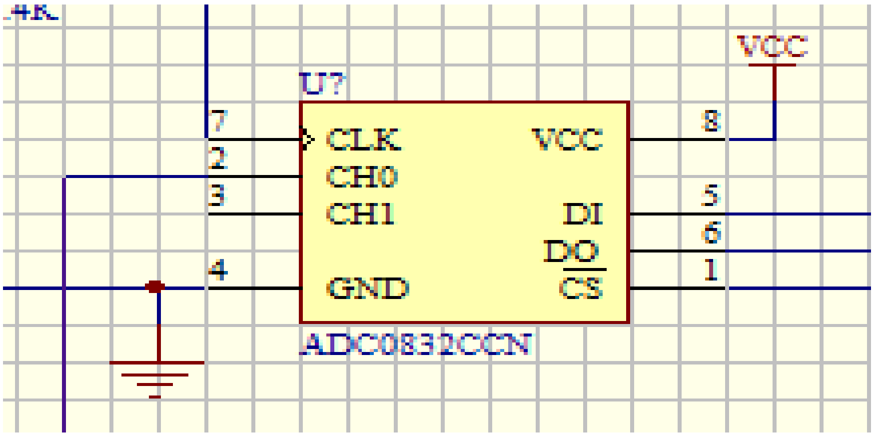

Figure 7. A/D circuit schematic diagram.

3.5 LCD module

In this design, the main detection is temperature and humidity and the concentration of PM2.5, and the range of the two needs to be set. There are a total of six data to be displayed, namely real-time PM2.5 concentration, real-time temperature and humidity, Preset PM2.5 concentration and temperature and humidity. In order to meet the needs of display, the display module of this system uses LCD1602 liquid crystal display [10]. The specific wiring diagram of LCD1602 is shown in Figure 8.

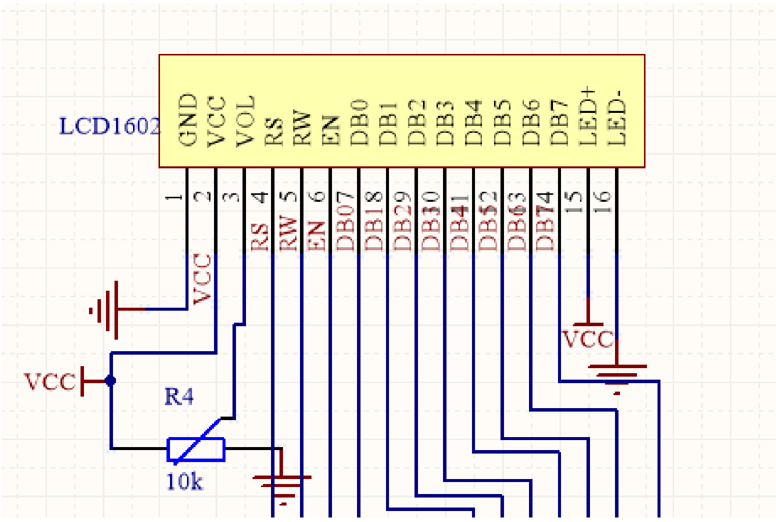

Figure 8. LCD circuit schematic diagram.

3.6 Buzzer module

The buzzer module is a highly integrated module. The active buzzer used in this article is composed of a triode amplifier circuit, a resistor and a horn. The emitter of the triode is grounded and the base is connected to the resistor. As shown in Figure 9.

ISSN: 2414-1895
DOI: 10.6919/ICJE.202011_6(11).0034

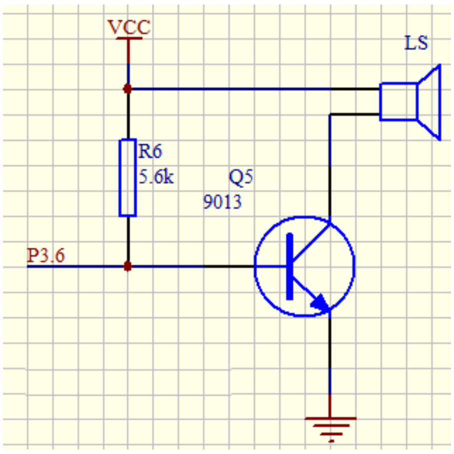

Figure 9. Alarm circuit diagram.

3.7 Button circuit module

This system shares three control buttons, namely KEY1, KEY2, KEY3. KEY1 is to enter the parameter setting mode, KEY2 is to increase the parameter setting, and KEY3 is to decrease the parameter setting. The design diagram is shown in Figure 10.

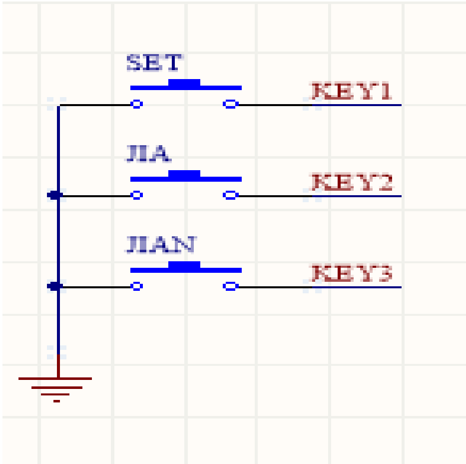

Figure 10. Button circuit diagram.

4. Simulation and hardware test results

4.1 Software simulation

The software program of this system is written in C language, and the circuit is built using Prooutus to check whether the circuit can operate normally in the simulation environment.

The circuit simulation steps are as follows,

(1) System initialization.

(2) The microcontroller sends a start signal.

(3) The sensor responds after receiving the start signal, until the end of the high level, the microcontroller can begin to receive data.

(4) The host starts to receive data.

(5) When the data line is pulled down for 50μs, the reading is over.

(6) Test data.

As shown in Figure 11, after running the simulation circuit, the system is initialized and enters the mode of setting the temperature and humidity monitoring interval, click the "minus" button to adjust the T1L value, click the "SET" pointer to jump to T1H, and set the interval value of each parameter in turn .

ISSN: 2414-1895
DOI: 10.6919/ICJE.202011_6(11).0034

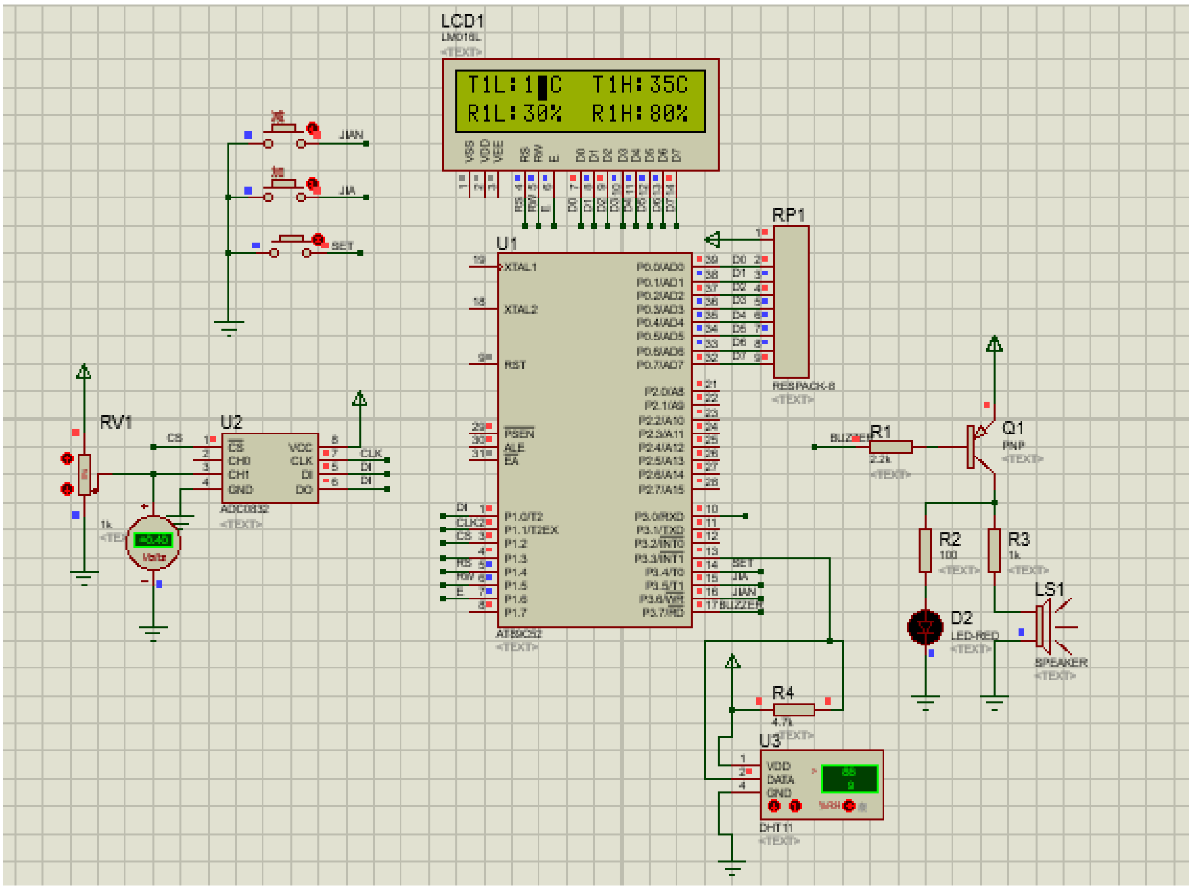

Figure 11. Simulation diagram setting mode.

4.2 Hardware test

(1) After connecting the 5V DC power supply to the designed system, the temperature and humidity sensor and PM2.5 sensor test the current temperature and humidity value and PM2.5 value in the air, showing that the temperature is 25°C, the humidity is 48%, and PM2 .5 is 80μg/m³, as shown in Figure 12.

Figure 12. System initialization.

Press the red button and the system enters the interface for setting the temperature and humidity value and PM2.5 value. Press the green button to increase the value, press the yellow button to decrease the value, and press the blue button to reset to the initial state. T1L is the lowest temperature, T1H is the

ISSN: 2414-1895 DOI: 10.6919/ICJE.202011_6(11).0034

highest temperature, R1L is the lowest humidity, R2L is the highest humidity, and HPM2.5 is the highest PM2.5 value. The lowest temperature shown in Figure 13 is 15℃, the highest is 35℃, the lowest humidity is 30%, the highest is 80%, and the highest value of PM2.5 is 200μg/m³.

Figure 13. Setting the threshold.

Add smoke to the PM2.5 sensor and the PM2.5 value raises to 773μg/m³. When it exceeds the preset 200μg/m³, the buzzer sounds an alarm, and the alarm continues until PM2.5 drops below 200μg/m³. The alarm sound stops, as shown in Figure 14.

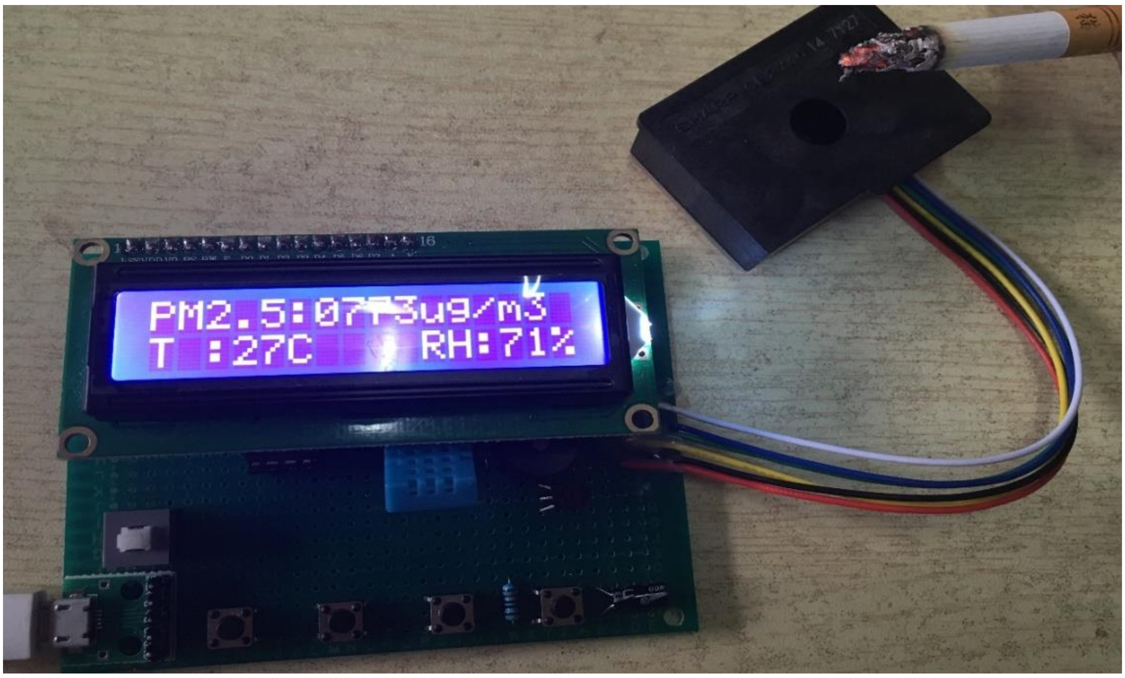

Figure 14. PM2.5 sensor plus smoke.

Use a lighter to heat the temperature and humidity sensor, as shown in Figure 15. When the temperature is 28℃ and exceeds the preset threshold of 15℃, the buzzer will alarm, and the alarm will continue until the temperature drops below 15℃.

ISSN: 2414-1895
DOI: 10.6919/ICJE.202011_6(11).0034

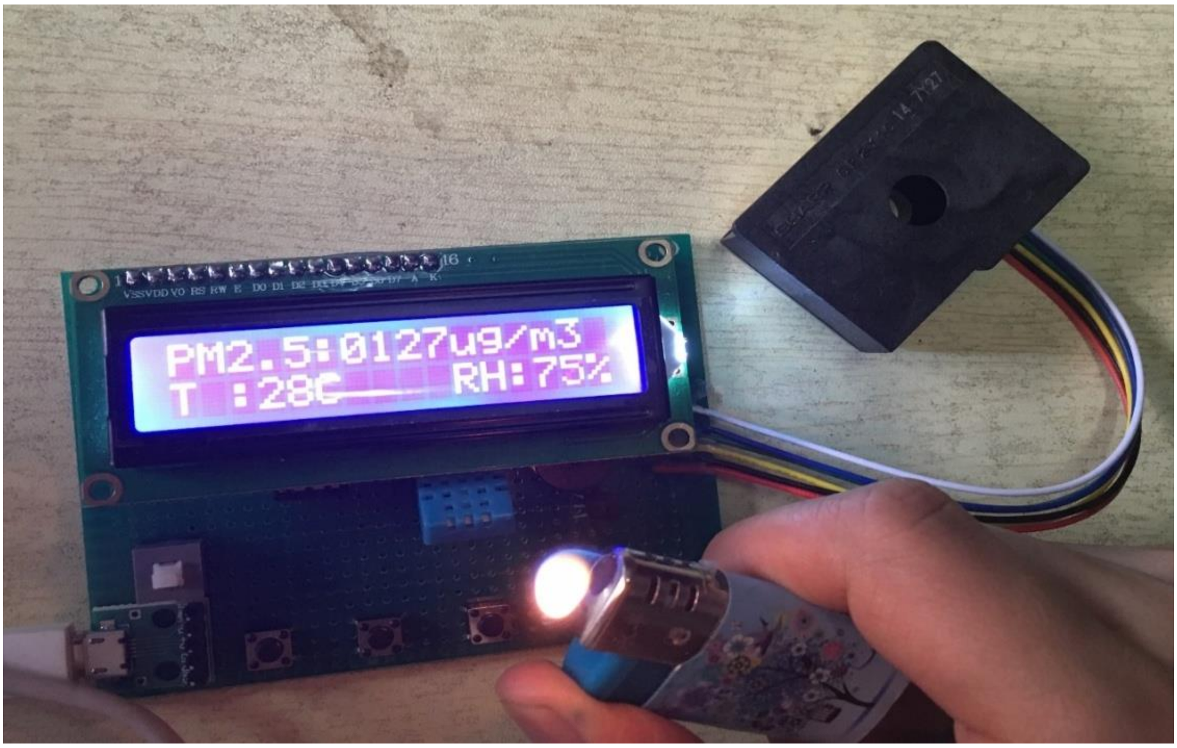

Figure 15. Heating temperature and humidity sensor.

5. Conclusion

This paper designs an indoor air quality monitoring system based on STC89C52 microcontroller, and conducts in-depth research on the specific hardware circuit, software simulation and hardware test. This system is mainly composed of a single-chip control system, analog-to-digital conversion module, alarm module, power supply module, temperature and humidity sensor module, PM2.5 sensor module, program download circuit, button module, and liquid crystal display module. The microcontroller is the core control module. Each sensor module collects data from the surrounding environment. The A/D module performs analog-to-digital conversion of the data. The LCD module displays the content to be displayed. The microcontroller analyzes and compares the data. The preset warning value controls the buzzer to alarm, the power circuit provides 5V power for the system, and the button module controls and switches the various functions that you want to achieve. After software simulation and hardware testing, the results show that the temperature, humidity, and PM2.5 value can be displayed and detected correctly, meeting the design requirements.

Acknowledgments

This work was supported by the National Natural Science Foundation of China (grant number 61901350); Science Research Fund of Xi'an Aeronautics University (grant number 2019KY0208).

References

[1] Fan Aobo, Tie Zhixin, Wu Mingcheng, Liu Lianggui. Design of indoor air quality monitoring system [J]. Journal of Zhejiang Sci-Tech University, 2015, 33(05): 382-389.

[2] Ding Yuehui. Design and analysis of indoor air quality monitoring system [J]. Building Engineering Technology and Design, 2018, (30): 756.

[3] Yang C, Liao C, Liu J, et al. Construction and Application of an Intelligent Air Quality Monitoring System for Healthcare Environment [J]. Journal of Medical Systems, 2014, 38(2): 15.

[4] Cai H, Ross L G, Telfer T C, et al. Modelling the Nitrogen Loadings from Large Yellow Croaker (Larimichthys Crocea) Cage Aquaculture [J]. Environmental Science and Pollution Research, 2016, 23(8): 7529-7542.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202011_6(11).0034

[5] Liu Chaoran, Zhu Zhu, Wei Fuhe, et al. Design of indoor air quality detection system based on LoRa [J]. Microcontroller and Embedded System Application, 2020, 20(6): 59-62.

[6] Chen Liang, Zheng Yuanzhi, Chen Lingchao. Design of indoor air purifier evaluation instrument based on Arduino single chip microcomputer [J]. Electronic Testing, 2018, (6): 36-37.

[7] Wang Zhihong. Design of laboratory multi-point temperature and humidity alarm system based on DHT11 [J]. Shanxi Electronic Technology. 2011.

[8] Ni Tianlong. Application of single bus sensor DHT11 in temperature and humidity measurement and control[J]. Microcontroller and Embedded System Application, 2010, 11(5): 45-50.

[9] Wang Qi. Research on PM2.5 sensor monitoring performance [J]. Building Thermal Ventilation and Air Conditioning, 2016, 4: 37-39.

[10] Chen Dongjie, Xu Zhongshi. Discussion on the design of single-chip indoor environment monitoring system [J]. Information Technology and Information Technology, 2017, 05: 131-133.