

Research and Design of Indoor Gas Automatic Regulation System based on STM32

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Abstract

Indoor air indicators such as temperature, humidity, formaldehyde, carbon dioxide, PM2.5 have a direct or indirect impact on health. Traditional air conditioners, humidifiers, fans and other home appliances have only a single regulating function, and cannot comprehensively improve and control the indoor air environment. This paper designs an air conditioning system based on STM32F103 microcontroller, which has the function of indoor air comprehensive regulation, and can automatically control the temperature, humidity, CO₂ and formaldehyde content in the room. This system uses HR202 and ultrasonic atomizer to monitor and regulate humidity, uses Midea brand air conditioning system and its open instruction system to control temperature, uses SGP30 and fresh air system to monitor and regulate CO₂ and formaldehyde. After comprehensive experimental tests, the system can effectively adjust the temperature to 18-30°C ($\pm 1^\circ\text{C}$), humidity effective control range of 50%-75%RH ($\pm 5\%$), CO₂ effective control within 1000 PPM, formaldehyde control within the range of 0.1mg/m³. Experiment has proved that the system can effectively regulate the indoor air quality, and can provide a green and healthy air environment for residents.

Keywords

Air Quality; Humidity Regulation; Temperature Regulation; Formaldehyde; Fresh Air System.

1. Introduction

With the development of science and technology, people pay more attention to the quality of life. More and more intelligent air conditioning household products have been invented, air quality has become a hot research topic today [1]. Air conditioners, humidifiers, fans and other household appliances have become indispensable for most people, but this kind of electrical equipment can only adjust a single parameter of the air [2].

This paper designs an intelligent air conditioning system, which can automatically adjust the air parameters such as temperature, humidity, formaldehyde and CO₂ gas. The system is different from the traditional air conditioner, humidifier and fan, and is a kind of integrated indoor air conditioning system. With STM32 as the control core, the system is equipped with multiple sensors and fresh air system, and combined with Midea brand air conditioning, to realize the comprehensive air conditioning function.

2. System block diagram and principle

2.1. System scheme

The whole system is roughly divided into eight modules. The system takes STM32F103 MCU as the control core; The temperature is adjusted by Midea air conditioning (through STM32 to send Midea open standard communication code infrared instruction code); Humidity is adjusted by ultrasonic atomizer and HR202 humidity sensor. CO₂ and formaldehyde regulation are by the SGP30 sensor and fresh air system; Button and LED LCD module are for input and output. The overall system block diagram is shown in Figure 1.

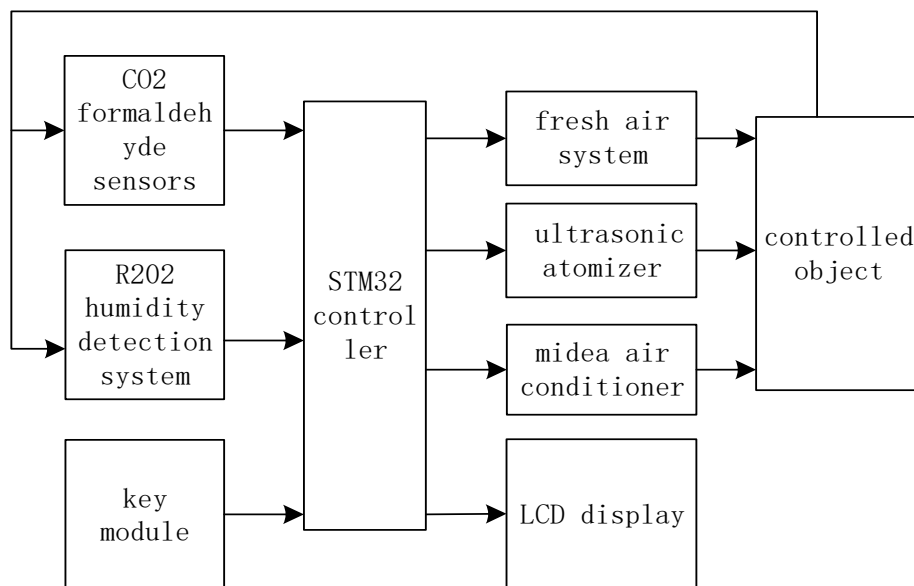


Figure 1. Block diagram of the system scheme

2.2. Temperature regulation

The system through STM32 to control the air conditioning to complete the temperature adjustment. STM32 drives the infrared transmitter tube and sends out the open infrared instruction to complete the temperature control. At present, the infrared remote control in the market is widely used in two forms of coding format, one is NEC infrared transmission PWM protocol (pulse width modulation) protocol, the other is Philips infrared transmission PPM (pulse position modulation) protocol [3]. This paper uses Midea brand air conditioner as the test object, and Midea air conditioner uses R05D protocol in NEC format. STM32 in the temperature control only plays a command output intelligent terminal, and the actual temperature control is completed by the air conditioning.

2.3. Humidity regulation

Humidity adjustment consists of two modules: ultrasonic atomizer and HR202 humidity detection sensor. Humidity is automatically controlled at 55-65%RH by default, and the humidity adjustment range can also be set manually through key input. When the HR202 detects that the humidity is lower than the preset value for 100 consecutive seconds, it will trigger the ultrasonic atomizer to produce moisture, and when the humidity is higher than the preset value, it will trigger the fresh air system to start and discharge moisture.

It should be noted that HR202 is a component that is sensitive to temperature changes and must be matched with thermistor to measure temperature [4]. The impedance characteristics of HR202 at different temperatures are shown in Table 1.

Table 1. HR202 temperature and impedance relationship table

	0℃	5℃	10℃	15℃	20℃	25℃	30℃	35℃	40℃	45℃
50%RH	370K	260K	200K	150K	115K	100K	87K	69K	56K	45K
55%RH	190K	140K	110K	84K	64K	69K	39K	33K	27K	24K
60%RH	105K	80K	62K	50K	39K	31K	25K	20K	17.5K	13K
65%RH	62K	48K	37K	30K	24K	19.5K	16K	13K	11.5K	8.6K
70%RH	38K	30K	24K	19K	15.5K	13K	10.5K	9K	8.0K	6.0K
75%RH	23K	18K	15K	12K	10K	8.4K	7.2K	6.2K	5.6K	4.2K

Table 1 provides HR202's discrete data indicators. In order to improve the accuracy, the discrete data indicators are fitted into a surface function through Matlab [5], and the following formula can be obtained:

$$Z = 114.086 + 0.0793 \times Y - 0.456 \times X - 13.170 \times \log(Y) \quad (1)$$

In the above formula, X is temperature in °C, Y is impedance in KΩ, and Z is humidity in %RH. STM32 collects humidity data every 10s and calculates whether it is within the preset range. If the humidity exceeds the preset value for 10 consecutive times, the humidity is considered unqualified. If the current humidity is higher than the preset value, the fresh air system will be turned on to drain moisture; otherwise, the ultrasonic atomizer will be turned on to humidify. Its flow diagram is shown in Figure 2

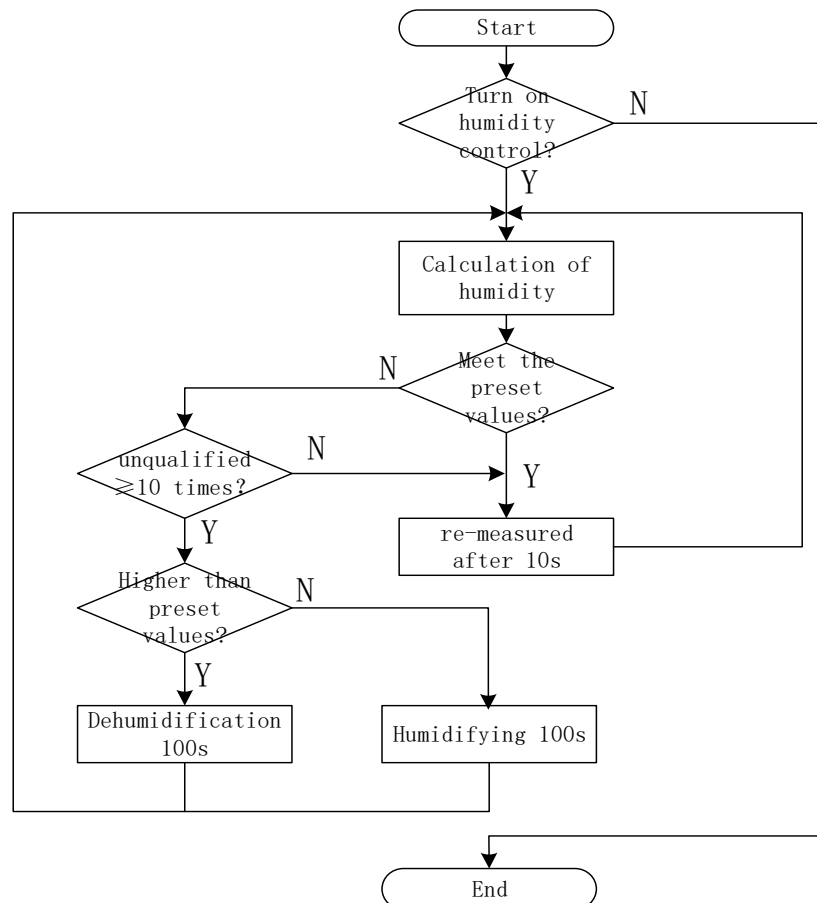


Figure 2. Flow chart of humidity regulation

2.4. Formaldehyde regulation and CO₂ regulation

SPG30 is used for formaldehyde and CO₂ detection. It communicates with STM32 through IIC and reads the gas value every 10S. When abnormal gas is detected for 10 consecutive times, the fresh air system will be triggered until the formaldehyde gas is discharged clean. Its

communication process is shown in 3. The detection procedure for carbon dioxide is similar to that for formaldehyde and will not be repeated here.

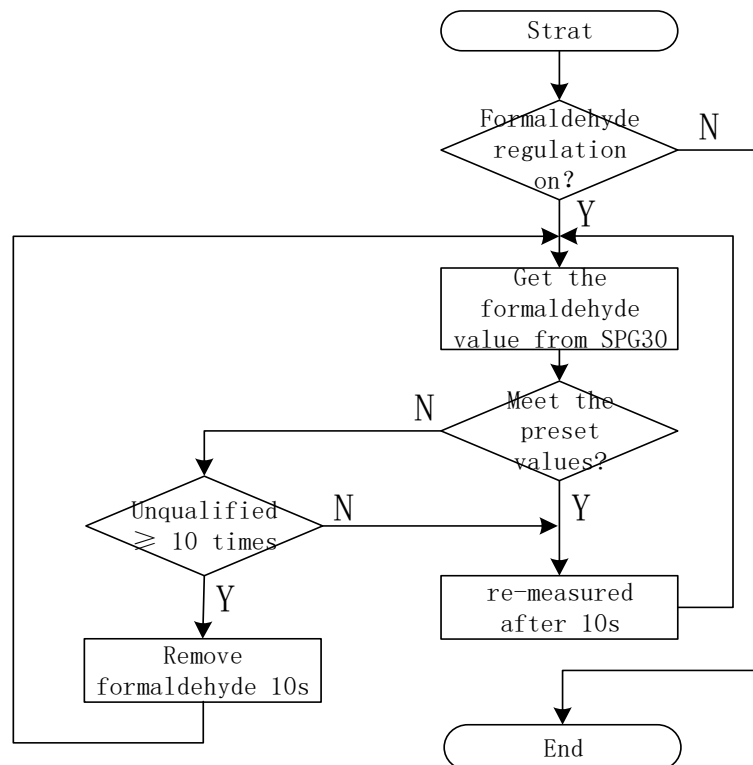


Figure 3. Flow chart of formaldehyde regulation

3. Experiment

3.1. Parameter standard

According to the relationship between air parameters and human health, STM32 is taken as the control core to achieve the following indexes:

- (1) Adjust the indoor gas temperature (16°C-30°C);
- (2) Adjust the indoor gas humidity (automatically adjust to 55-65%RH(±5%));
- (3) Adjust indoor CO2 content (automatically adjust to ≤1000 PPM);
- (4) adjust the indoor formaldehyde content (automatically adjust to ≤0.1mg/m³, according to the national standard GB/T18883-2002 "indoor air quality standards"[6]).

3.2. Temperature control test

Test tools: DRETEC brand thermometer, model O-296WT, Midea brand air conditioner.

The remote control distance is 5 meters, the temperature command is 16-30°C, and the wind speed command is 1-3 level. After testing, it is found that the temperature error is within ±0.5°C. Because the temperature control is determined by the quality of the air conditioner itself, the core of this test is whether the remote control is normal, and the measured control system can accurately remote control the Midea air conditioner. After testing, the system sent 100 infrared commands, and the air conditioning responded.

3.3. Humidity control test

Test tools: hegao brand humidity tester, model TH1010

Set the humidity control target at 55%-65%RH, higher or lower than this value will trigger the dehumidification or humidification function. The test results are shown in Table 2

Table 2. Humidity trigger test

Humidity trigger level(%RH)	Trigger times (100)
≥67%	100
66%	92
55-65%	0
54%	88
≤53%	100

3.4. CO₂ control test

Test Tool: Robock Air Tester, Model AR8299

The humidity control target is controlled within 1000ppm, and our goal is to set CO₂ higher than 950ppm to open the fresh air system. The trigger value is 950ppm.

Table 3. CO₂ trigger test

CO ₂ trigger level(ppm)	Trigger times (100)
≥1000	100
980	86
960	9
940	4
≤940	0

3.5. Formaldehyde control test

Test tools: Wade brand formaldehyde tester, model WFHL-03

According to the Chinese national standard GB/T18883-2002 Indoor Air Quality Standard, formaldehyde within 0.1mg/m³ is a safe value. The program set the goal to detect formaldehyde higher than 0.090mg/m³ to start the fresh air system.

Table 4. Formaldehyde trigger test

CO ₂ trigger level(mg/m ³)	Trigger times (100)
≥0.110	100
0.090	78
≤0.070	0

4. Conclusion

This paper studies the indoor air conditioning system based on STM32 microcontroller system. The system uses STM32F103 microcontroller, humidity sensor, CO₂ sensor and formaldehyde sensor to realize the comprehensive air quality regulation function of the room. LCD display displays in real time, and when the air parameter exceeds the preset value, it will trigger the alarm; At the same time, it can also automatically or manually control the adjustment device by pressing the key. When the system is set to automatic control, if the environmental conditions are higher than the safety value, the alarm device will be turned on to remind the user, and the air will be automatically purified. When the environmental conditions are reduced to an acceptable range, the operation of the air conditioning unit will be stopped. The experimental results show that the system has a very intelligent and integrated air handling ability, and has a positive effect of purifying air and improving human health.

Acknowledgments

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