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STM32-Based Intelligent Temperature and Humidity Monitoring System Design

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Abstract: In this paper, an intelligent temperature and humidity monitoring system based on STM32 microcontroller is designed. The system uses STM32F103C8T6 as the main controller, and the DHT11 sensor collects ambient temperature and humidity data, displays it in real time through the OLED display, and uses the buzzer to realize the over-limit alarm function. The experimental results show that the system has high measurement accuracy, fast response speed and low cost, and is suitable for temperature and humidity monitoring in agricultural greenhouses, warehousing and logistics, smart home and other scenarios.

Keywords: STM32; temperature and humidity monitoring; DHT11 sensor; embedded systems; Intelligent control

1 INTRODUCTION

Temperature and humidity are important physical parameters that affect the quality of production and living environment. In agricultural planting, food storage, precision manufacturing and other fields, accurate monitoring of temperature and humidity is of great significance to ensure product quality and improve production efficiency. Traditional monitoring methods rely on manual inspection, which has problems such as low efficiency, large errors, and poor real-time performance.

With the development of IoT technology, intelligent monitoring systems based on microcontrollers have been widely used due to their advantages such as low cost, small size and strong function. The STM32 series microcontrollers have the characteristics of high performance, low power consumption, and rich peripheral interfaces, making them the mainstream choice for embedded system development.

In this paper, a temperature and humidity monitoring system based on STM32 is designed to realize the real-time collection, display and alarm functions of environmental parameters, providing a cost-effective solution for related applications.

2 OVERALL SYSTEM DESIGN

2.1 SYSTEM ARCHITECTURE

The system adopts modular design, mainly including: main controller module, sensor acquisition module, display module, alarm module and power supply module. The system architecture is shown in Figure 1.

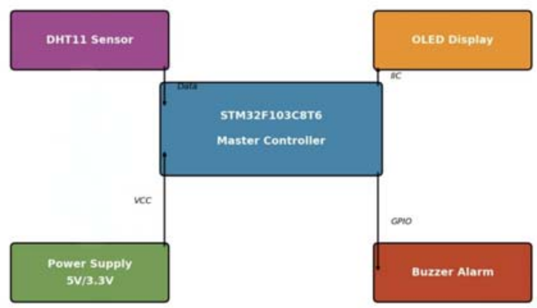

FIG.1 SYSTEM HARDWARE ARCHITECTURE

2.2 HARDWARE SELECTION

Main controller：STM32F103C8T6，ARM Cortex-M3 kernel Main frequency72MHz，64KB Flash，20KB RAM[4]

Temperature and humidity sensor: DHT11, measuring range temperature 0-50° C, humidity 20-90%RH, accuracy ±2° C/±5%RH[5]

Display module: 0.96-inch OLED display, IIC communication interface, resolution 128×64.

Alarm module: active buzzer, low level trigger

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Power Module: 5V DC power supply, converted to 3.3V power supply by AMS1117-3.3

3 HARDWARE CIRCUIT DESIGN

3.1 MAIN CONTROL CIRCUIT

STM32F103C8T6 minimum system includes: clock circuit (8MHz crystal + 32.768kHz crystal), reset circuit, BOOT boot circuit, and download and debug interface (SWD). The system operates at 3.3V, which is converted from 5V to 5V by LDO regulator chip AMS1117-3.3.

3.2 SENSOR INTERFACE CIRCUIT

The DHT11 uses a single-bus protocol for communication, and the data cable is connected to the PA0 pin of the STM32, which requires an external pull-up resistor of 4.7k Ω. The sensor supply voltage is 3-5.5V, and the power consumption is extremely low, making it suitable for battery-powered scenarios.

3.3 DISPLAY AND ALARM CIRCUIT

The OLED display communicates with STM32 through the IIC interface, with SCL connected to PB6 and SDA connected to PB7. The buzzer control terminal is connected to PA1, which is driven by NPN triode to achieve over-limit sound and light alarm.

4 SOFTWARE PROGRAMMING

4.1 MASTER PROGRAM FLOW

After the system is powered on, first initialize each peripheral module (GPIO, USART, IIC, TIM). In the main loop, DHT11 data is read every 2 seconds, the OLED display is updated, and an alarm is determined. The procedure flow is shown in Figure 2.

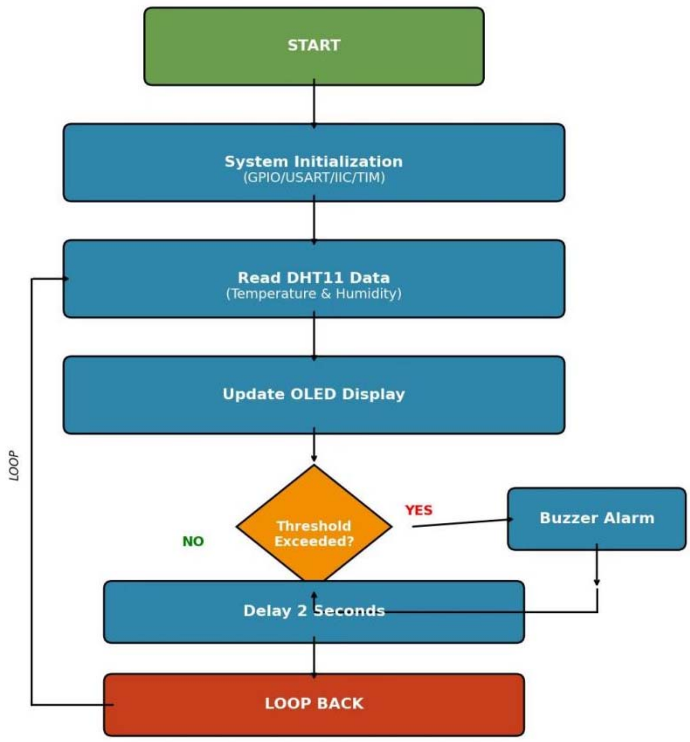

FIG.2 MAIN PROGRAM FLOWCHART

4.2 KEY CODE IMPLEMENTATION

DHT11 data reading adopts a single-bus timing sequence, and strictly follows the 18ms start signal and 40-bit data format specified in the protocol (8bit humidity integer + 8bit humidity decimal + 8bit temperature integer + 8bit temperature decimal + 8bit checksum). The key code logic is as follows:

```
DHT11 data reading function
u8 DHT11_Read_Data(u8 *temp, u8 *humi) {
  u8 buf[5];
  DHT11_Rst(); Send a start signal
```

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```
    if(DHT11_Check() == 0) { // Detect response
        for(u8 i=0; i<5; i++)
            buf[i] = DHT11_Read_Byte();  Read 40-bit data
        if((buf[0]+buf[1]+buf[2]+buf[3]) == buf[4]) { // 校验
            *humi = buf[0];
            *temp = buf[2];
            return 0;  Success
        }
    }
    return 1;  Failed
}
```

4.3 *ALARM THRESHOLD SETTING*

The system sets the upper temperature limit of 35° C, the lower limit of 10° C, the upper limit of humidity of 80%RH, and the lower limit of 30%RH. When the monitoring value is out of range, the buzzer sounds for 3 seconds, and the OLED displays the alarm information.

5 SYSTEM TESTING AND RESULT ANALYSIS

5.1 *TEST ENVIRONMENT*

Laboratory environment, temperature 25±2° C, humidity 60±10%RH. A standard thermohygrometer (accuracy ±0.5° C/±3%RH) was used as a reference for comparison. The physical test device of the system is shown in Figure 3.

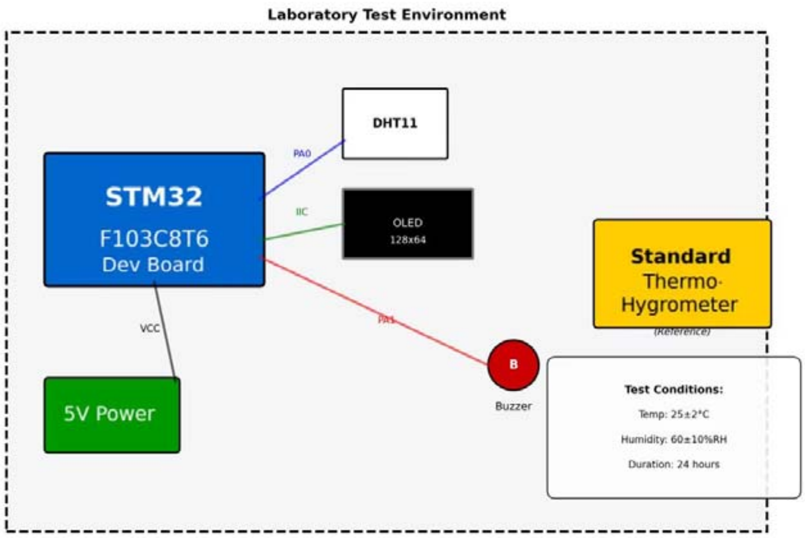

FIG.3 PHYSICAL TEST SETUP OF THE MONITORING SYSTEM

5.2 *TEST RESULTS*

Continuous monitoring for 24 hours, the system records data every 2 minutes.

TABLE 1 THE STATISTICS RESULTS

Parameters	The mean of the system measurement	Standard mean	Absolute error	Relative error
temperature	24.8℃	25.1℃	0.3℃	1.2%
Humidity	58.6%RH	61.2%RH	2.6%RH	4.2%

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5.3 ANALYSIS OF RESULTS

The test results show that the temperature measurement error of the system is less than ±2° C and the humidity error is less than ±5%RH, which meets the nominal accuracy of the DHT11 sensor. The system response time is less than 2 seconds, the data is updated stably, and there is no packet loss. The alarm function is tested 10 times, and the triggering accuracy is 100%.

6 CONCLUSION

The temperature and humidity monitoring system based on STM32 designed in this paper has a simple hardware structure, low cost (the cost of the whole machine is less than 50 yuan), and the software design is modular and easy to expand. The system realizes real-time monitoring, display and alarm functions of temperature and humidity, and the measurement accuracy meets the needs of general applications.

Future work can be considered: (1) the use of DHT22 sensor to improve the measurement accuracy; (2) Add WiFi/GPRS module to achieve remote monitoring; (3) Added data storage function to support historical data query.

REFERENCES

[1] Wang L, Zhang H. Design of greenhouse environment monitoring system based on wireless sensor networks[J]. Computers and Electronics in Agriculture, 2020, 169: 105178.

[2] Liu Y, Chen X, Wang Z. IoT-based temperature and humidity monitoring system for smart agriculture[J]. IEEE Access, 2021, 9: 45678-45689.

[3] STMicroelectronics. STM32F103x8 datasheet: Medium-density performance line ARM-based 32-bit MCU with 64 or 128 KB Flash, USB, CAN, 7 timers, 2 ADCs, 9 communication interfaces[EB/OL]. (2015-08-01)[2026-03-15]. https://www.st.com/resource/en/datasheet/stm32f103c8.pdf.

[4] Li Ming, Wang Qiang. Development and Application of Embedded System Based on STM32[M]. Beijing: Electronics Industry Press, 2022: 45-78.

[5] Aosong Electronics. DHT11 humidity and temperature sensor datasheet[EB/OL]. (2020-03-10)[2026-03-15]. https://www.aosong.com/userfiles/files/media/DHT11%20Datasheet.pdf.

[6] Solomon Systech. SSD1306 128 × 64 dot matrix OLED/PLED segment/common driver with controller datasheet[EB/OL]. (2018-05-01)[2026-03-15]. https://www.solomon-systech.com/files/ssd1306.pdf.

[7] Zhang Wei, Liu Yang. Microcontroller Principle and Interface Technology[M]. Beijing: Tsinghua University Press, 2021: 112-135.

[8] Brown T, Davis K. Embedded systems design: An introduction to processes, tools, and techniques[M]. 3rd ed. New York: CRC Press, 2019: 89-102.