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Design of Monitoring System for Cold Chain Insulation Box

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Abstract: **With the development of society and the improvement of the quality of life, all kinds of food and medicine need to be stored and transported by cold chain incubators, and the requirements for temperature and humidity in the storage and transportation process are very high. Through the investigation and Research on the cold chain transportation, the structure of the incubator, the temperature and humidity monitoring system and the national GSP certification, the overall plan of the design is confirmed, and the design of the hardware, the software design and the design results are described in detail. This system uses STM32 as the main controller, using a high precision temperature and humidity sensor to monitor the value of real-time temperature and humidity, through Bluetooth serial communication to realize data transmission and with alarm function. Through multiple debugging of the system, the value of temperature and humidity can be displayed and recorded in real time, and the history records can be printed by the Bluetooth printer, which meets the national GSP certification and meets the design requirements.**

Keywords: Cold chain incubator; Temperature and humidity; STM32 MCU

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1.Introduction

The monitoring system of the cold chain insulation box is designed to create a suitable environment for the storage of all kinds of food and drugs, and to ensure the safety of the quality of the goods in the cold chain insulation box. Since the strict requirements of the storage environment are critical to the items in the incubator, any abnormal changes in temperature and humidity will have a serious impact on the quality of the items in the incubators. Therefore, when the temperature and humidity in the incubators are not suitable for storage, Timely and effective measures should be taken to regulate the environment in the insulation box. When the cold chain insulation box is used for transportation, the quantity of goods is large and the precision is high. The monitoring system of the cold chain insulation box can realize the real-time monitoring of the temperature and humidity value in the insulation box, and can be used to monitor the temperature and humidity value in the insulation box. Early warning is enough to minimize the loss if an accident is more likely to be determined. through the design of the monitoring system of the cold chain insulation box, the problems of poor real-time performance of the article cold chain logistics, disconnection of supervision, difficulty in obtaining evidence, large loss rate and the like are solved[Zhiqiang Chen, et. al., 2015].

2 System Scheme

2.1 overall structure and function of the system

The system designed in this paper takes STM32 single chip microcomputer as the core, collects the feedback information of the sensor, records the real-time temperature and humidity value, displays and stores the data through the liquid crystal. Alerts are issued when temperature and humidity are out of range (temperature and humidity alarm ranges can be modified by keystrokes) and historical data can be printed through a Bluetooth printer when needed.

2.2 system scenario analysis

2.2.1 selection of major control devices

Scheme I: single chip computer chooses STM32F103. STM32 to have enough storage space and low power consumption, its Cortex-M3 kernel can meet the requirement of high design requirement and low cost of embedded application, and STM32F103 is the enhanced version of ARM core[Dengshan Zhou, et. al., 2017].

Scheme II: single-chip microcomputer AT89C51. AT89C51 is not only easy to operate but also widely used. It is a 4-byte programmable erasure read-only memory, but needs to be added to the A / D conversion chip.

Scheme III: STC12C5A60S2 single-chip microcomputer. STC12C5A60S2 has faster processing speed, lower power consumption and super-strong anti-interference ability. The instruction code and programming mode of the single-chipcomputer are completely compatible with 51 single-chip computer, so it is called 8051 single-chip microcomputer-enhanced version, which is convenient to use, simple in operation and easy to learn.

To sum up, although the operation of AT89C51 and STC12C5A60S2 single chip microcomputer is simple, but the storage space is relatively small, and the design of embedded application design is also higher, so the STM32F103 single chip microcomputer is chosen as the main controller of the monitoring system of cold chain insulation box.

2.2.2 selection of sensors

Scheme 1: DHT11 temperature and humidity sensor. DHT 11 is a temperature and humidity coincidence

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sensor which can calibrate the output of digital signal, mainly because of the special digital module acquisition technology and temperature and humidity sensing technology in the sensor. So the reliability and stability of DHT11 sensor is high. DHT 11 sensor is mainly composed of two parts: resistance humidity sensor and NTC temperature sensor. Overall, the product has the advantages of quick response, strong anti-interference ability, its humidity error is ±5% RH, temperature error is ±2 ℃, and the ratio of performance to price is very high.

Scheme 2: SHT21 temperature and humidity sensor. HT21 sensor is the smallest sensor of temperature and humidity sensor. SHT21 sensor integrates sensitive elements on 3*3mm substrate, calibration memory and digital interface. And the use of coating molding technology to make appearance. The environmental protection material is used to make the shell, which is made of silicon and can detect the low power state by itself, which greatly improves its stability and reliability. The error of temperature value of HT21 is ±0.5 ℃ and the error of humidity value is ±0.3% RH, the error of temperature value of HT21 is ±0.5 ℃, and the error of humidity value is ±0.3% RH. Can meet a variety of requirements for high-precision conditions of the application.

The monitoring system of the cold chain insulation box should conform to the national GSP certification, and has higher requirements for the accuracy of the temperature and humidity measured by the sensor: the error of the temperature value should be controlled at ±0.5 ℃. The error of humidity value should be controlled in ±0.5%RH.DHT11 temperature and humidity sensor's precision is not up to the standard, so SHT21 temperature and humidity sensor is more suitable for this design.

2. 2. 3 Selection of display

Scheme 1: LCD1602 liquid crystal display. LCD 1602 liquid crystal display can display letters, symbols and other relatively simple code, it is easy to control, the cost is relatively low, is the best choice for low-cost display module. But displaying Chinese characters is more cumbersome.

Scheme 2: LCD12864 LCD display. LCD 12864 LCD display can contain a Chinese font inside, can display complete Chinese characters, graphics. Its low voltage, low power consumption and circuit structure, the programming is also relatively simple, the operating temperature is in the range of 0 ℃ ~ 55 ℃.

Scheme 3: 2.2inch TFT liquid crystal display. TFT liquid crystal is a relatively modern liquid crystal, TFT is a thin film liquid crystal display, it can display high contrast screen information, not only good brightness but also a strong sense of hierarchy. But the power consumption is relatively high, the cost is also relatively high.

To sum up, although LCD1602 is low in cost and can also display temperature and humidity values, it does not satisfy the large number of Chinese characters that need to be displayed in this design, and LCD12864 can complete all the contents that need to be displayed, but considering that the application site may be tested at low temperatures, Its temperature index is not up to standard. TFT liquid crystal has higher power consumption and higher cost. In order to make the display interface more comprehensive, normative and normal operation, after comprehensive consideration, This design selects 2.2-inch TFT liquid crystal display as this design display.

2.2.4 Choice of Bluetooth Communication

Scheme 1: HC05 wireless Bluetooth module. HC05 wireless Bluetooth module power supply voltage is 3.3V / 3.6V, it chooses the main Bluetooth chip of CSA as chip, and the standard protocol of Bluetooth is V2.0. The advantage is that the operation is relatively simple. Users do not need to know any Bluetooth protocol, after Bluetooth pairing can be directly used as full-duplex serial port. However, it supports a limited communication format, the only supported communication format is 8-bit data bit, 1-bit stop bit, no parity.

Scheme 2: SIM800C module. SIM800C is a quad-frequency GSM/GPRS module, its appearance is small, is the size of 17.6*15.7*2.3mm castle hole package structure. Its stable performance, low power consumption for data transmission, voice, SMS and Bluetooth functions, can be applied to a variety of compact product design requirements. It is a communication module with extremely high cost-for-money ratio.

In conclusion, the SIMO800C is powerful, and the Bluetooth serial communication function can be fully realized, and the space is also expanded. The HC05 function is limited, although the content of this design can be realized but is limited in the extended space. the sim 800c module is selected to implement the bluetooth communication function.

3. System Hardware Design

3.1 Master Controller Modul

3.1.1 introduction to STM32 single Chip Microcomputer

Single chip microcomputer can be said to be a small and perfect computer system. It uses very large scale integrated circuit (VLSI) technology to integrate various I / O ports and interrupt systems, timing / timer, and random access memory (RAM,). The read-only memory (ROM) and the central processor (CPU) with data processing ability are integrated into a silicon chip

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to form a circuit chip, which can connect the peripheral devices to realize the required functions[Mingxin Chen, et. al., 2013].

The STM32 series adopts ARM Cortex-0 core, its operating range is-40 ℃ ~ 85 ℃, its power supply voltage is 2V / 3.6V, with its own security clock mode and wake-up function. In application, it comes with internal RC oscillation and reset circuit, so it is more convenient to use embedded application. Although STM32 has low cost, it is not inferior to the realization of function, and users have a great choice in low-cost budget application. The STM32F103 schematic diagram

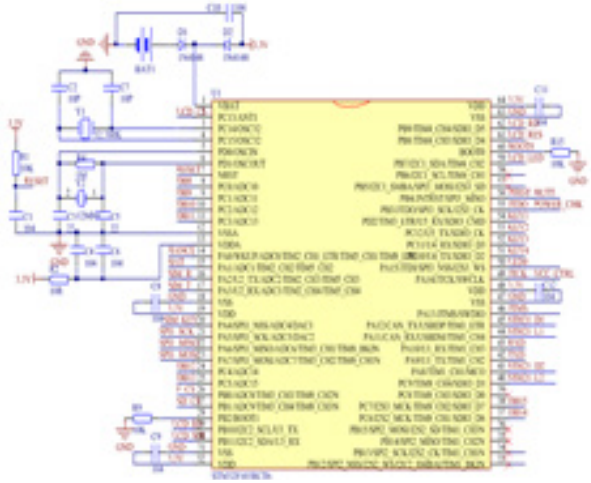

Figure 1 STM32F103 schematic

in this design is as shown in figure 1.

3.1.2 minimum system circuit

The minimum system circuit of the STM32 is composed of a microcontroller, a clock circuit, and a reset circuit. The clock circuit, the crystal oscillator, is the core of the clock circuit, and is the core of the microcontroller's operation. The operation of the oscillator does not work or the oscillation is irregular, which will directly result in the microcontroller not working or the operation is abnormal. The internal integrated RC oscillator of the STM32 single-chip microcomputer is used as a clock source and can be directly used, and in general, an external crystal oscillator is not required. The clock circuit in this design uses the external crystal vibration of 12MHZ and 32.768KHz, one as the high-speed clock and the other as the low-speed clock.

CPU and all parts of the system need to work from the initial state, which requires the MCU to reset at startup to ensure this state. The reset function of STM32 is easy to achieve: when the system is in a normal state, If the RST pin has a high level and maintains more than two machine cycles, the reset signal is sent out and the system reset after the CPU response.

3.2 temperature and humidity sensor module

The working principle of the temperature and humidity sensor is relatively complex, which is simply the conversion of the sensed analog signal through the physical properties of the substance (the rule of change with temperature and the content of water vapor in the sensing gas). Finally, the temperature and humidity of the environment are converted into output signals. The core part of temperature and humidity measuring instrument is temperature and humidity sensor, which has many kinds. Thermocouple, thermistor, resistance temperature detector (RTD) and IC temperature sensors are the four main types of temperature sensors, while humidity sensors are mainly resistance type and capacitive type [Zhilin Jiang, 2015].

This design uses SHT21 temperature and humidity sensor, temperature and humidity separately to collect, they have the same pin function, send and receive data through I2C. The data line SDA and the clock signal line SCL (pin 2, 3 in the design temperature and humidity schematic diagram) are two major components of the I2C bus. The transmission mode between the CPU and the controlled IC is bi-directional. The control signal released by CPU in the process of transmission is composed of two parts: address code and control quantity. The role of the address code is to determine the type of control and to complete the control circuit (temperature and humidity sensors have And there is only one address; the type of control (temperature, humidity) is determined by the amount of control. In the process of data transmission, I 2C bus can send out three different types of signals: start signal, end signal and reply signal. When a signal is received by the controlled unit, a response signal is released to the CPU. After receiving the response signal from the controlled unit, the CPU makes a judgment according to the actual situation. The 40,41,44,45 of the main controller are connected with the pins 2 and 3 of the temperature and humidity sensor, respectively, to realize I 2C data reception, the power supply of the No. 1 pin, and the grounding of the No. 4 pin.Schematic diagram of temperature and humidity sensors as shown in figure

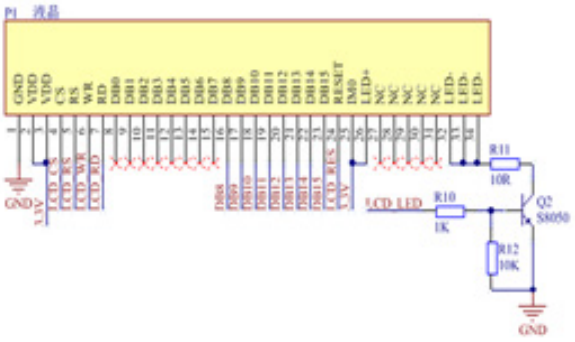

Figure 2 schematic diagram of temperature and humidity sensor

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3.3 display Modul

This design uses 2.2-inch TFT liquid crystal display. TFT is short for thin-film crystal liquid crystal display. Each node of TFT is relatively independent and the display color is relatively bright. Because each pixel is equipped with a semiconductor switch, and these switches can be directly controlled by point pulses and even continuous control, which makes it display a large increase in the reaction rate, and color level control is more accurate. In structure, TFT liquid crystal uses environmental protection material, no radiation, no harm to human body, it can be used normally in the temperature range of-20 ℃ ~ 50 ℃.

The schematic diagram of TFT liquid crystal is shown in figure 3.

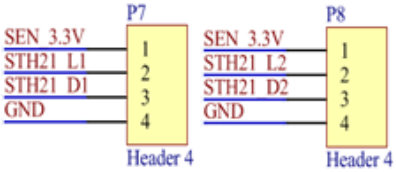

Figure3 TFT liquid crystal schematic diagram

As shown in the pin menu, the TFT LCD pin 1 is grounded in this design, and the 2nd and 3rd feet are connected to 3.3V power supply; the fourth pin of the TFT liquid crystal is the chip selection input pin, which realizes the connection between the liquid crystal and the single chip microcomputer through the second pin of the main chip; The number 5 pin of TFT LCD is the input pin of instruction / data selection. It is connected with the 29 pin of the main control to realize the data transmission between the main controller and the liquid crystal. The 6 and 7 pins of the TFT LCD are read / write strobe signals respectively. They are connected to the 30 and 62 pins of the main chip, respectively, to mark the address of the memory cell and facilitate the extraction and access of the memory cell. The 16 / 23 pin of TFT liquid crystal is the data bus, which is connected to the DB8-DB15 pin of the main chip to realize the transmission of the whole data in the system. The 24 pin of TFT LCD is the reset pin, and the 61 pin of the main chip is connected to the main chip to realize the reset function, and the 32 / 34 pin of the TFT liquid crystal is backlit and introduced by the 59 pin of the main chip.

3.4 Communication Modul

The communication system designed in this paper needs to be realized by SIM800C module. SIM800C comes with Bluetooth module, and Bluetooth serial communication function is realized by standard AT instruction. When using Bluetooth serial communication function, baud rate is 115200, 8bit data, 1bit stop, no check.

SIM800C 34, 35 pin power supply, 36, 37 feet ground; SIM800C No. 1 pin for transmitting data pin, 2 pin for receiving data pin, they are connected with the main chip of the number 17, 16 pins, so as to achieve serial communication data reception and transmission; In this design, the Bluetooth printer is the Bluetooth printer. The 15 pin of the SIM 800C is the input and output pin of the SIM card data, and the 16 pin of the SIM800C is the SIM clock pin. Pin 17 is the SIM reset pin. No. 18 pin for SIM power supply pin, this design does not require SIM design requirements, so do not do too much description.The schematic diagram of SIM800C in this design is shown in figure 4.

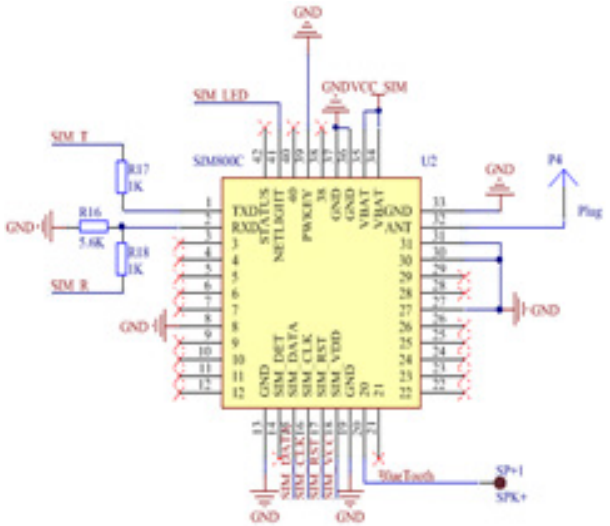

Figure 4 SIM800C schematic

3.4.1 SIM800C Module Featur

The main results are as follows:

(1) the input voltage range 5V~20V DC, power supply range is suitable for all kinds of power supply situations, and it is more convenient to use in students and engineering projects.

(2) the boot-up process is simple and does not require a button. After the power-on, it starts directly and connects to the network, reserving the boot-up pin, so that the user can control the switch-on machine himself.

(3) Module TTL with level conversion circuit, compatible with all kinds of single-chip microcomputer serial port. There is no need to convert direct connections.

(4) lead-out of audio interface, convenient to test, reserved earphone and microphone interface.

(5) support the function of TTS\ DTMF, which can recognize each other's buttons directly through language broadcast and call, and realize and 10086 speech station function. (6) Bluetooth function, Bluetooth 3.0 protocol, enhanced Bluetooth antenna signal, support serial port SPP and audio service.

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(7) reserving lithium battery-powered BAT interface, which can be powered by lithium battery, which is convenient for engineering development. 3.7 V lithium battery or 18650 lithium battery.

4.SOFTWARE DESIGN

4.1 Main programming

This design is a hardware physical design, but the hardware needs to be matched with the software to make the hardware work freely. So the software in this design of the cold chain insulation box monitoring system is the most important. The following software parts will be designed in this design: main judgment program, TFT liquid crystal program, temperature and humidity sensor program, key program, clock program, serial communication program and so on. The main judgment program is designed as priority, and each program is added on the basis of the main judgment program. In the design method, the analytical method is used to judge the impact of a program, and the structural design is used to reduce the occurrence of errors. It also reduces procedural confusion and complexity.

Long press on key to power the system, after about 2 seconds, the system goes into initialization, the components start to work. The temperature and humidity sensors sense the temperature and humidity values of the environment in which they are located, and display the measured results on the TFT liquid crystal and store historical data through the memory if the temperature and humidity detected are outside the prescribed range (the temperature and humidity provisions can be modified by a button). The buzzer will ring, the alarm light will light up, the value beyond the specified value will turn red; If you need to hit the stored imprint value, you need to turn on the Bluetooth connection to the Bluetooth printer and print the historical data through the Bluetooth printer.

4.2 Subprogramming

4.2.1 Design of temperature and humidity Sensor

After the SHT20 temperature and humidity sensor detection module works properly, it detects the temperature and humidity of the current environment in real time, and sends the collected data to the AXD conversion section of STM32. The conversion of temperature and humidity values is completed by the A / D conversion part of STM32, and the converted values are sent to the CPU of STM32. The converted values are analyzed and processed by the CPU of STM32 and the records are stored[Guonan Hu, 2018]. The flow chart of the temperature and humidity sensor is shown in figure 5.

4.2.2 Design of Bluetooth Communication

The SIM800 series modules are compatible with various hardware versions, and most of the main AT instructions are the same as those of the other models of

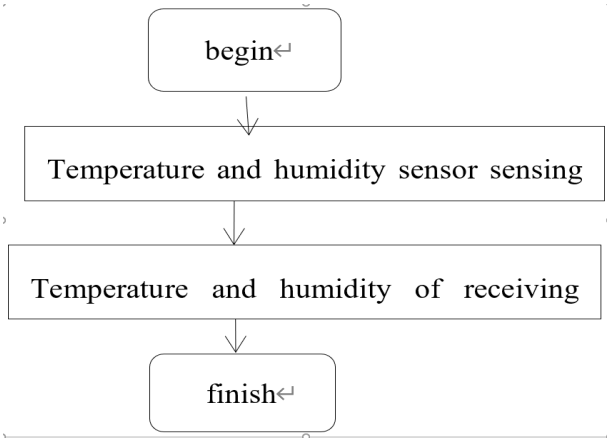

Figure 5 Sensor workflow diagram

SIM Com. USART initialization of the chip is relatively simple, can use the standard function library of STM32 to initialize the baud rate, complete the corresponding clock and GPIO configuration. STM32 can output data through serial port, and transmit the information to SIM800,SIM800 through Bluetooth communication. Connect Bluetooth printer, print history temperature and humidity value [Hong Zhu, et. al., 2018].

The Bluetooth printer is turned on and connected to the main system, the communication enters the initialization state, the SIM800C sends the history value of the temperature and humidity in the memory to the Bluetooth printer, and the Bluetooth printer receives the data. In the process of data transmission, SIM800C determines whether the data is sent or not, if the time-out is sent, it retransmits the data. After sending the data, the Bluetooth device receives the complete data and presses the print key after receiving the data, so that the printing of the data can be realized.

5 .TAG

The monitoring system of the cold chain insulation box is designed to create a suitable environment for the storage of all kinds of food, drugs and so on, and to ensure the safety of the quality of the goods in the cold chain insulation box. The real-time monitoring of the temperature and humidity value in the insulation box can be realized, and early warning can be achieved. If accidents occur, it is easier to determine the responsibility, so that the loss can be minimized.

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