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Design and Implementation of Intelligent Door Control System

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Abstract

In order to meet the requirements of safety and reliability, an intelligent access control system was designed with STM32 as the core. This system uses STM32 as the main control unit and combines a card swiping module, non-contact temperature measurement circuit, and infrared obstacle avoidance module; OLED display module, Bluetooth module, independent button module, providing intelligent control for users. Through testing, users can unlock using methods such as card swiping and Bluetooth. During the unlocking and unlocking process, it is necessary to first find a person and then use non-contact temperature measurement to determine whether the current temperature is within the set range. This plan has practical guidance on the safety and reliability of the access control system.

Keywords

Swipe card password lock; OLED; Non contact temperature measurement; singlechip.

1. Introduction

With the development of sensor technology and microcontroller technology, password lock technology has also made significant progress. Previously, it was unlocked through electronic passwords, but without matching, it cannot be unlocked. It greatly enhances the security performance of the encryption system, and users must use the corresponding card on the corresponding key, otherwise they cannot unlock it. At present, there are various mature electronic locks, including card swiping, voice, card swiping, etc. However, current electronic locks cannot achieve remote control, so they are generally located on cabinets, boxes, or furniture. In view of the current importance of property and various confidentiality measures, an in-depth exploration has been conducted on the existing access control system, aiming to maintain its advantages while improving its drawbacks; Therefore, it is necessary to have higher security, simpler operation, and higher reliability[1-5].

As early as over a thousand years ago, the Greeks and Romans improved traditional unlocking methods by opening locks. At that time, locks were made of iron, and unlocking only ensured that the corresponding lock could be opened. In 1824, Halysorif invented the world's first lock, and in 1857, James Sargent invented a smart door that could be opened within a certain time frame and a door that could be opened within a certain time frame. Nowadays, electronic locks can use digital passwords or card swiping methods. Currently, an electronic lock that can be scanned by a mobile phone or unlocked through voice is being developed. The overseas Schlache company has developed a device that allows users to use Bluetooth and operate electronic locks through a phone. With the continuous development of integrated circuit technology, sensor technology, and microcontroller technology, the biggest change in current electronic locks is that their size continues to shrink and their safety factor continues to increase. Although the current locking capacity is relatively small, more convenient to operate, and more secure; Its price is very high, so its popularity is very low, mostly in high-end

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residential areas, and it is still in use. The majority of the power consumption of electronic locks comes from the power supply, which limits their application range greatly[5-11].

In foreign countries, the development level of electronic locks is much higher than in China, and its auxiliary systems are also relatively complete, so its application is very extensive, and its security is also very high. At present, the electronic access control technology in China is still in the 1960s and 1970s, and most of it is achieved through buttons and keychains because of its high cost. If manufactured in large quantities, it will allow enterprises to obtain lower profits. With our further research on electronic locks, our electronic locks will be greatly developed.

This article designs an intelligent gate control system, which includes the programming of a microcontroller, card recognition, contactless temperature measurement, infrared obstacle avoidance, and display modules; Relay module, independent button module, etc. The hardware design of the system can complete basic tasks such as opening and closing doors, swiping cards, and temperature measurement. In addition to the above functions, this system also has the characteristics of shutdown protection, card swiping, and unlocking.

2. Design scheme

Using STM32F103C8T6 as the main control unit, its core is Cortex-M3, which uses a processor with a total of 48 pins and can accommodate 64K of storage space. There are currently two types of I2C interfaces that can adapt to settings where many users have relatively low requirements for system performance, and this model is currently being manufactured on a large scale, making its price even lower; Moreover, manufacturers will also prepare more library functions for users, allowing them to save a lot of time in practical operations.

The design uses a 0.96-inch LCD module OLED, which is composed of OLEDs. Its main function is to control 128 * 64 light spots through LEDs to meet the needs of users. The display content of this module is more diverse, with higher contrast, brighter colors, and a wider perspective; The present invention adopts a method that can view the content displayed by the display module in real-time from multiple perspectives, and has smaller, lighter, and lower power consumption; Currently, various display modules are commonly used, and their communication modes are relatively simple. The main serial communication modes used are SPI and IIC.

The construction of a matrix keyboard is quite cumbersome, but it requires a shorter time. The matrix keyboard includes row and column lines, with buttons located at the intersection of rows and columns. If the button is not pressed, the row line is high and the column line is low; If a key is pressed, the column line and row line are connected, and the level of the row line depends on the level of the column line connected to this row line. In this way, when using a small number of function keys, a separate keyboard can be used; In the case of a large number of buttons, a matrix approach can be used to achieve this. This design uses more buttons and selects a separate button for selection.

The design uses a microcontroller as the core controller, along with other modules, to form the entire access control system, including the central control part, input part, and output part. The central control part adopts a microcontroller controller, whose main function is to obtain data from the input part, undergo internal processing, logical judgment, and ultimately control the output part. The input consists of five parts. The first part is the infrared obstacle avoidance module, which detects whether there is currently someone through this module; The second part is a non-contact temperature measurement module, which detects the current body temperature; The third part is the button module, which allows for interface switching, threshold setting, and more; The fourth part is the power supply module, which can provide power to the entire system. The output consists of three parts. The first part is the display module, which can display the monitored data and set thresholds; The second part is the relay

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module, which detects someone and has a normal body temperature. After the card swiping comparison is correct, the relay controls the lock to open; The third part is the sound and light alarm module, which provides an sound and light alarm when abnormal temperature is detected.

3. Hardware description

Use STM32F103C8T6 circuit, including power circuit, crystal oscillator circuit, and reset circuit; Download circuit, start circuit, composed of multiple components; In this design, a voltage reduction module is used to reduce the voltage from 5V to 3V. The chip consists of two parts: one is the crystal oscillation circuit of MCU, and the other is the crystal oscillation circuit of RTC; The function of the main crystal oscillator circuit is to input clock signals into the interior of the microprocessor. This design adopts 8M parameters, and its main function of the external capacitor is to make the crystal oscillator simpler. The function of the resistor is to make the clock work more smoothly; The crystal oscillator circuit is the smallest type of microcontroller, which can provide a 1HZ clock signal to the core of the microprocessor. This time, a 32.768HZ crystal was used, and after frequency division, it can obtain a 1HZ frequency and provide power to the RTC. Its function is the same as the main control crystal; Its function is to oscillate the capacitor, which causes the system to vibrate with the crystal at the moment of power on, causing the quartz crystal to oscillate, and then output a high frequency of 32768 Hz. The microprocessor reset circuit is composed of button capacitors and resistors. When the button is removed, the reset circuit has two high-level cycles; After the microcontroller is powered on, it charges and discharges the capacitors and resistors, causing a lower level when the microcontroller is powered on, thereby resetting the microcontroller; In this way, the microcontroller can automatically reset after being powered on, and the system can reset when the button is pressed. The schematic diagram of the main control chip is shown in Figure 1.

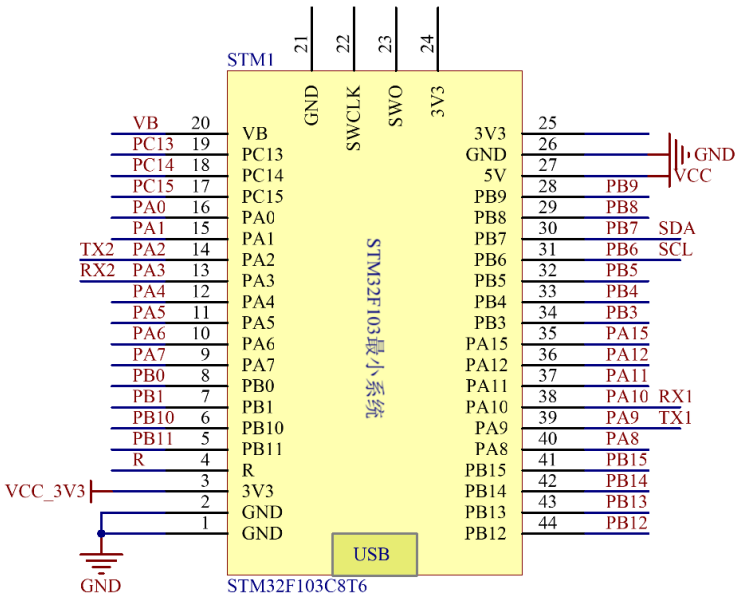

Fig.1 Schematic diagram of the minimum system of a microcontroller

The RFID system adopts an RC522 radio frequency identification card, and its card reader is composed of a PhilipsMFRC522 chip, which can be used for device development and card reader development at a low price. This system also uses a 3.3V power supply, which can communicate directly with the user's CPU motherboard and ensure the stability and reliability of the system's operation. The physical object of this module is shown in Figure 2.

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Fig.2 RC522 RF Module

Draw a schematic diagram based on the RC522 RF module, as shown in Figure 3. The RFID signal pins are P33-P37, and the power supply is 3.3V. The P33 pin function is for reset and breakpoint input pins, the P34 pin function is for I2C protocol interface, the P35 pin is for SPI mode and can be connected to the peripheral of the serial port, the P36 pin is for SPI pulse signal, and the P37 pin is for input SPI and UART signal data serial port.

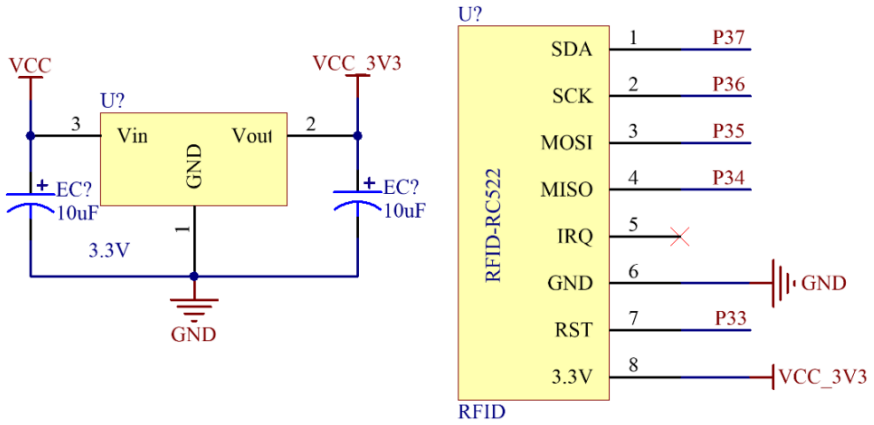

Fig.3 Schematic diagram of RC522 module

The MLX90614ESF non-contact sensor used for measuring human body temperature mainly detects human body temperature through infrared technology, similar to the IIC communication method, called SMBus; Like IIC, the collected data is transmitted to the MCU through SDA and SCL, processed accordingly in the MCU, and displayed on the screen using a simple algorithm. Like DS18B20, the pins connected to the MCU must be connected with resistors to prevent the microcontroller from being pulled up. This is not shown here, as the resistors have already been drawn on the module, the same process is not being carried out; This method mainly uses infrared sensors to obtain the heat of the measured object, convert it into electronic signals, and then use amplifiers to amplify the electronic signals; Finally, the analog digital signal is converted into a digital signal, sent to the microprocessor for processing, and then converted into the corresponding temperature, which is displayed on the display screen. Its working principle is to use an infrared thermoluminescent sensor to detect the infrared emitted by the human body after the human body approaches the infrared detector; Different infrared radiation from the human body can cause voltage changes in the sensor, but the detected signal is relatively weak, so amplification is required in the later stage. If the temperature is below the set maximum value, an audible and visual alarm will be triggered. The circuit module is shown in Figure 4.

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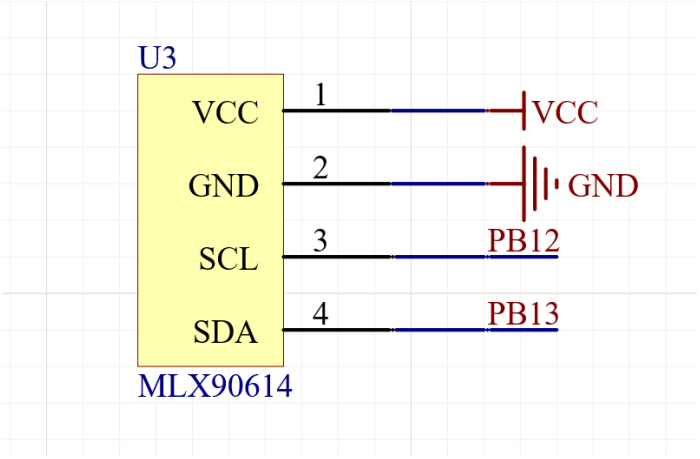

Fig.4 Circuit schematic diagram of non-contact temperature measurement module

The display module on the host of this system uses a 0.96 inch 128 * 64 OLED display module. The screen is internally integrated with an SSD1306 driver chip, which is connected to the ARM main control chip through an SPI interface. This module has the advantages of small size, low power consumption, and easy development, making it particularly suitable for small embedded devices.

This design uses one relay to control the opening or closing of the door lock. The circuit of the relay is shown in the figure below, by connecting relay 1 to the microcontroller PB15. The function of connecting a transistor in the relay is to amplify the current of the microcontroller output pin, but the transistor amplification does not have negative feedback, causing the current to increase. In order to prevent the current output by the transistor from being too large, a resistor is connected in series before the transistor to limit the current. The role of connecting a diode in the relay is to ground the excess current, which can also serve as an indicator light for relay operation, When the relay is working, the diode lights up, and the schematic diagram of the relay circuit module is shown in Figure 5.

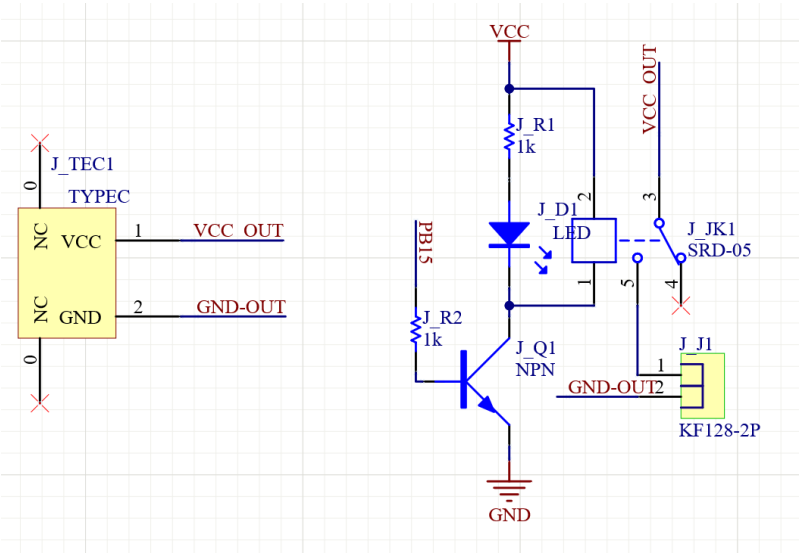

Fig.5 Relay Module Circuit

The design uses buttons to switch the display interface and set the upper and lower limits of normal temperature. This design requires fewer buttons, so independent buttons are selected as the key module for this design. The key is to better control the operation of the buttons and enter the mode of setting the upper and lower limits of human body temperature. The pin connections of the microcontroller are shown in Figure 6.

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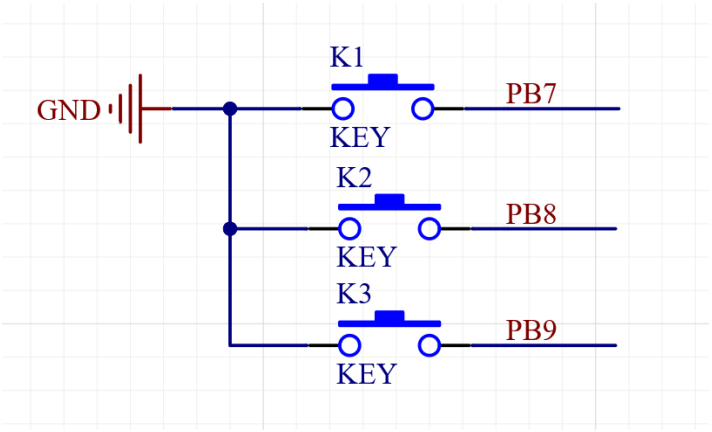

Figure 6 Schematic diagram of independent button circuit

4. Software description

This design uses Keil5, which is more convenient and fast compared to other development environments. Keil5 is widely used by developers of embedded systems. This platform provides HEX files generated by various microcontrollers such as 51, STM32, and HC32. HEX files can be directly written into microcontrollers by a burner, making it very convenient to use. In addition, the compilation of Keil5 is divided into three categories: single code, partial code, and full code compilation. These functions allow developers to better operate, and a compilation effect will appear at the bottom of the interface.

In the main program: first initialize each module, then enter the while main loop. In the main loop, first enter the first function button function, which is mainly divided into two parts. The first part is to call the button scanning function to obtain the key value, and the second part performs corresponding processing operations through the key value, including switching interfaces, setting thresholds, etc; Next, enter the second function monitoring function, which mainly obtains measurement values by calling the corresponding driver function, and the device executes corresponding processing based on the instructions sent by the user; Next, enter the third function display function, which displays the monitoring value and threshold; Finally, enter the fourth function processing function to detect the card in real time and detect the temperature of the wrist. If the temperature is abnormal, there will be an audible and visual alarm, otherwise the door will open.

Firstly, define the key pins and initialize the pin status. Next, determine whether the mode flag bit is 1. If it is 1, it supports continuous pressing mode, and mark the button status at position 1. Then determine whether the button status flag bit is 1 and the button pin is low level. If both conditions are met, a delay of 10ms will be applied for shake suppression, and the button status flag position will be set to 0. Judge again whether the key pin is low level. If it is low level, press the key to return to the corresponding key value. If the key status flag bit is not 1 or the key pin is not low, it is determined whether the key pin is high. If it is high, the key is raised, the key status flag position is 1, and then returned to 0. If the key pin is not at high level, the key is not raised and returns to 0 directly.

First, set the slave address, and then pass in a series of initialization commands, including setting the memory addressing mode, setting the display clock frequency division factor, setting the multiplex transmission rate, starting line, display offset, contrast, charge pump, display mode, etc. After initialization, start to display data. First, set the starting coordinates of the display, then call the font array to compare the font array to find the displayed font, and call the write data function, So as to display the data.

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5. Physical commissioning

The physical image of the intelligent access control system designed this time is shown in Figure 7. From the physical image, it can be seen that the design includes the STM32 microcontroller and its minimum system, display module, independent button module, infrared obstacle avoidance module, non-contact temperature measurement module, RFID module, relay, sound and light alarm, power supply and other modules.

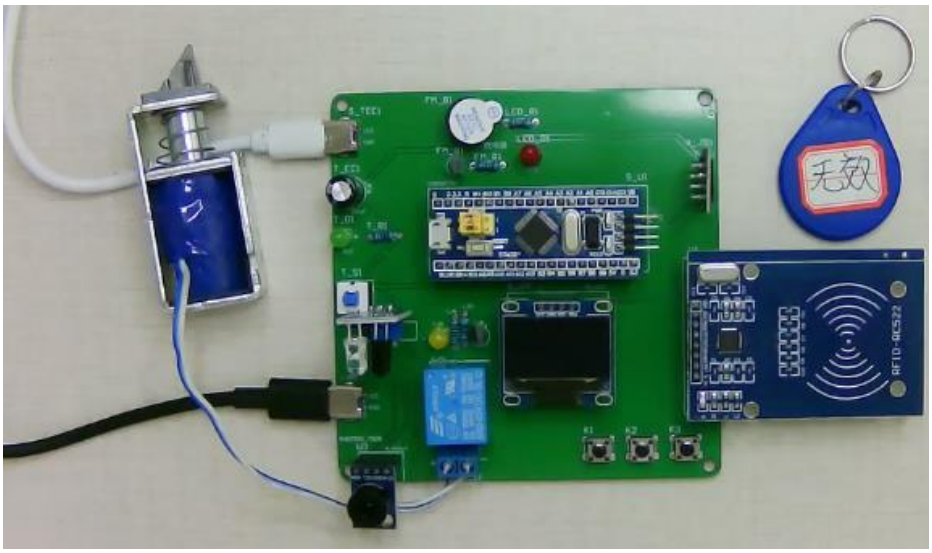

Fig.7 Overall physical welding diagram

6. Conclusion

This article takes STM32 as the core and provides an overall design and implementation of each power circuit, including the programming of a microcontroller, card recognition, contactless temperature measurement, infrared obstacle avoidance, and display modules; Relay module, independent button module, etc. The hardware design of the system can complete basic tasks such as opening and closing doors, swiping cards, and temperature measurement. In addition to the above functions, this system also has the characteristics of shutdown protection, card swiping, and unlocking. The designed control system has simple operation, low cost, and wide applicability. Some modifications and organization have been made to the power circuit design of the paper, meeting the basic design requirements. After swiping the card, the user must first identify the person and ensure that the temperature is at normal temperature before opening the door. Due to the inconvenience of using a digital password to unlock and easily forgetting it, this design did not add this feature. This system uses a microcontroller as the main control unit and combines it with other hardware functions to make the system more intelligent and secure; And the system has the advantages of simple structure, convenient operation, and low cost.

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