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Design of Access Control System Safety with Multiple Password Control

Zaiqun Wu[1], Huanchang Qin[1,*], Xiaomei Song[1] and Yuyu Feng[1]
[1]School of Information Engineering, Baise University, Baise, Guangxi, 533000
[*]Corresponding author

***Abstract*—Adopting STC12C5A60S2 single-chip microcomputer as the control core, the access control system of a safe with multiple password control consists of fingerprint recognition, GSM-SIM900A, 24C02 storage, LCD12864 liquid crystal display, motor drive, keyboard, and sound-light alarm modules. Experiments showed that the system could accommodate 200 fingerprint data. The fingerprint recognition time was less than 0.4s; rejection rate less than 1%; and false recognition rate less than 0.001%. After passing digital password and fingerprint identification, the system sent a verification code to the user's mobile phone. When the code was verified, the system started stepping motor to open access control. The system entered frozen state with sound-light alarm if the error of digital password or fingerprint identification was three times. The alarm was sent to the user's mobile phone at the same time. The system had the functions of multiple password protection, remote monitoring and alarming, with a high security and practicality.**

Keywords—safe; digital password; fingerprint password; remote monitoring

I. INTRODUCTION

With the development of technologies and economy, people need to store more assets, valuables or precious metals. However, traditional mechanical anti-theft safes can no longer meet people's needs, thus resulting in the emergence of intelligent-control safe system. Such system has become the inevitable development direction of security systems. Zhibin Feng [1] proposed safe protection through various measures, including mobile phone, digital password, fingerprint identification and image acquisition in the Design of Two-way Multi-protection Intelligent Safe. Yaowei Wu [2] believed that safe products using biometric identification technology such as fingerprints are characterized by high confidentiality and much convenience. The smart home safe designed by Xiaoming Shi [3] adopted fingerprint sequential passwords and mobile phone passwords to form double insurance. Na Lin [4] adopted H.264 video coding technology and RTP/RTCP protocol to realize the design of remote intelligent safe system. Wei Cheng [5] used fingerprint, RFIC and password to realize the design of triple authentication access control system. The safe access control system designed in the work uses STC12C5A60S2 single-chip microcomputer as the control core. It has functions of digital password, fingerprint identification, mobile phone verification, remote monitoring and alarm, with high safety factor and strong practicability.

II. OVERALL DESIGN OF THE SYSTEM

The system is mainly composed of hardware and software. Wherein, hardware mainly includes minimum system of single-chip microcomputer, fingerprint identification module, GSM-SIM900A module, 24C02 storage module, LCD12864 liquid crystal display module, motor drive module, keyboard module, sound-light alarm module, etc. Software mainly consists of button scan module, digital cryptographic module, fingerprint identification module, GSM module, freeze function module, stepper motor drive module, LCD12864 display module and 24C02 storage module. Figure I shows the system frame.

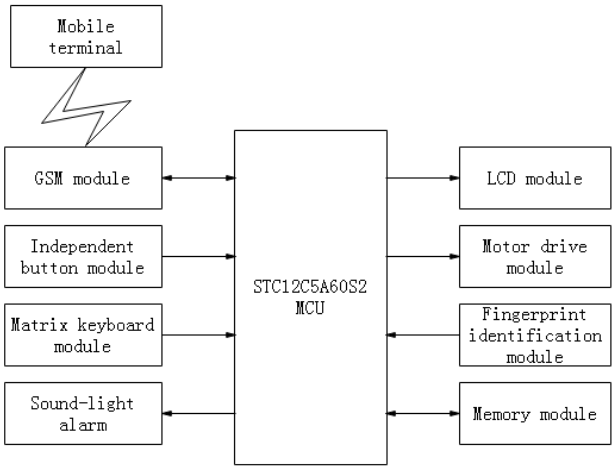

FIGURE I. SYSTEM FRAME

Using the system for the first time, the user needs to complete following steps: installing SIM card, setting digital password and collecting fingerprint information. Then, the system enters normal working state. If correct digital passwords are input, the system enters fingerprint collection and matching stage. A verification code is sent to the user's mobile phone after successful fingerprint matching. Correctly inputting the verification code, the user can open the safe access control system. Figure II shows working process of the system.

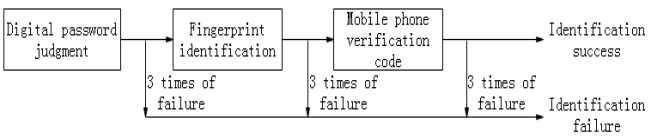

FIGURE II. WORKING PROCESS OF THE SYSTEM

III. HARDWARE DESIGN OF THE SYSTEM

The hardware part of the system mainly includes minimum system of single-chip microcomputer, fingerprint identification, GSM-SIM900A, 24C02 storage, LCD12864 liquid crystal display, motor drive, keyboard and sound-light alarm modules. STC12C5A60S2 single-chip microcomputer is adopted as the core control device. The functions involve setting and identification of control password, collection and recognition of fingerprint, data storage and display, on and off of access control system, and remote monitoring and alarm.

A. Fingerprint Identification Module

The atk-as608 optical fingerprint recognition module is adopted in the system, which involves DSP operation in the chip. Fingerprint recognition algorithm can be integrated to quickly process the collected fingerprint images. The module is controlled by single-chip microcomputer P3.0 and P3.1 two-bit I/O ports to capture and identify the fingerprint. That is, the communication between fingerprint identification module and the single-chip microcomputer is achieved through serial port 1 of the single-chip microcomputer. Collected by fingerprint identification module, the fingerprint data is processed through single-chip microcomputer. The data is stored in the 24C02 storage module.

B. GSM Module

SIM900A is used as GSM module in the system for information feedback and remote monitoring. The communication with single-chip microcomputer is achieved through the serial port 2 (P1.2 and P1.3). After the system is powered on, the validity of SIM card is checked to determine normal operation of GSM module. When using the system, the string “AT+CMGF = 1 \r” is sent to GSM module through the serial port 2, setting the mode of short message as TXT. Then, we set the user's mobile phone after sending “AT+CMGS = user mobile phone number\r”. Next, the short message to be sent is assigned to GSM module. Finally, the hexadecimal 0x1A (carriage return) is sent to confirm information transmission. Thus, the information verification and alarm function is finally realized by GSM module [6].

C. Design of Button Module Circuit

The button module circuit is composed of a matrix keyboard and independent buttons. The matrix keyboard consists of 4 rows and columns of tact switches, including 0~9 digits, *, Clear, Open, Close, Change Password and Confirm. The four independent buttons involve Confirm, ID+, ID-, and Exit. The buttons are mainly used for system setting, such as fingerprint collection and modification, and setting and input of digital passwords. ID+ and ID- are modifications of the fingerprint of an ID. Figure III shows the key function.

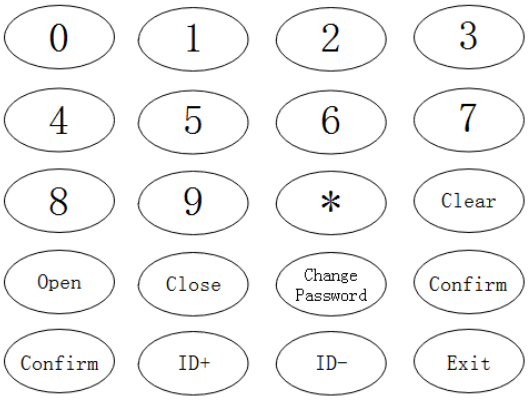

FIGURE III. KEY FUNCTIONS

D. Design of Storage Circuit

The AT24C02 memory produced by Atmel Company was adopted in the memory circuit. It is a low-power CMOS serial mode EEPROM, with characteristics of fast writing speed and retaining data after outage. Figure IV shows the storage circuit.

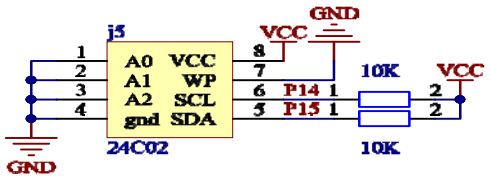

FIGURE IV. STORAGE CIRCUIT

The SCL (serial clock bus) and SDA (serial data bus) of the memory are connected to P14 pin and P15 pin of STC12C5A60S2 microcontroller, respectively. The SCL and SDA are controlled by I/O port of single-chip microcomputer to obtain different combinations of high and low levels. Therefore, the storage circuit can selectively perform the functions of data transmission, detection of acknowledge bits, data reading and data writing.

E. Design of Stepper Motor Drive Circuit

ULN2003 was used as the driving of stepper motor. The control of stepper motor needs to be realized by logic circuit. Through programming to command ULN2003, we can achieve control of the motor's operating mode, direction and speed. The opening of access control system is controlled by the motor controls. The motor turns on access control system after the triple passwords are verified.

IV. DESIGN OF SYSTEM SOFTWARE

The system software consists of keyboard scan, digital password, fingerprint recognition, GSM, freeze function, stepper motor drive, LCD12864 display, 24C02 storage modules, etc.

A. Design of Main Program

Main program of the system is the entrance of the whole program. After entering the main program, the system firstly initializes the information of LCD, serial communication and buttons. Then, keyboard scan is performed. After that, the system judges whether the mode of open access control is

turned on. If yes, the system enters the triple password unlocking process of digital password, fingerprint identification, mobile phone verification. If not, it is judged whether password modify mode is turned on. The password modify function is called in terms of “yes”. Otherwise, the system judges whether it is in fingerprint modify mode. The fingerprint modify function is performed in terms of “yes”. Otherwise, the system returns to the step of key scan. When the errors of digital passwords or fingerprint recognition reach three times, the system enters the freeze function with sound-light alarms. Meanwhile, an alarm message is sent to the user's mobile phone. Timer interruption is used in the freeze function to control the freeze time. The memory is adopted to record the remaining time. After passing digital password and fingerprint identification, the system sends message authentication password to the user. The system controls the motor to open access control after the verification password is correctly input. Figure V shows flow chart of the main program.

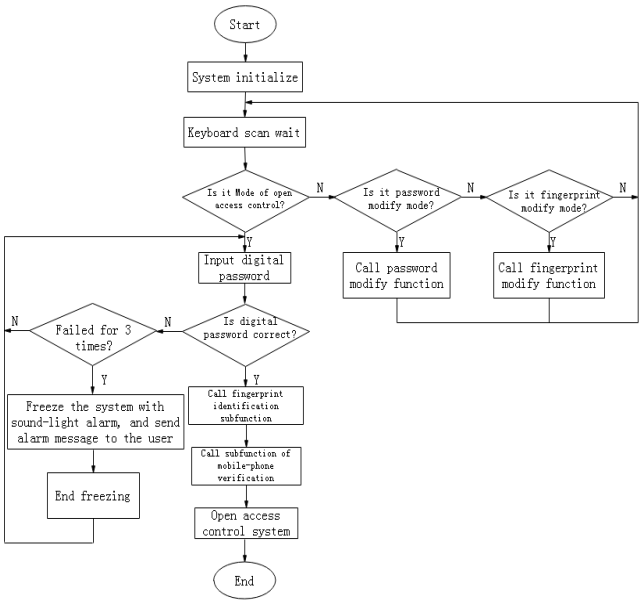

FIGURE V. FLOW OF THE MAIN PROGRAM OF THE SYSTEM

B. Design of Fingerprint Recognition Subroutine

In fingerprint identification module, the fingerprint image is collected through optical signal. Then, the fingerprint image is preprocessed to extract graphic feature value of the fingerprint. Finally, the fingerprint is compared with the stored database. The system enters the next process if the feature value is matched. Otherwise, “re-enter your fingerprint” is prompted. Figure VI shows the subroutine of fingerprint identification.

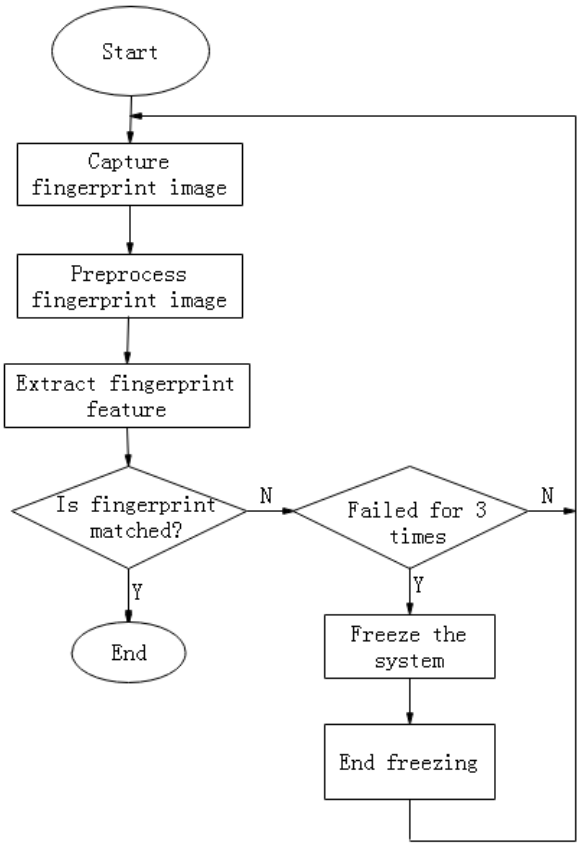

FIGURE VI. FLOW OF FINGERPRINT IDENTIFICATION SUBROUTINE

C. Subroutine Design of GSM Module—Mobile Phone Verification

GSM module communicates with the single-chip microcomputer through the serial port. Single-chip microcomputer can control working mode and communication content of GSM module by sending the labeled AT command through the serial port. Figure VII shows the flow chart of mobile phone verification subroutine. Wherein, the delay waiting is designed to ensure that GSM module has enough time to register to the network. Thus, it can normally communicate with SIM card of the user.

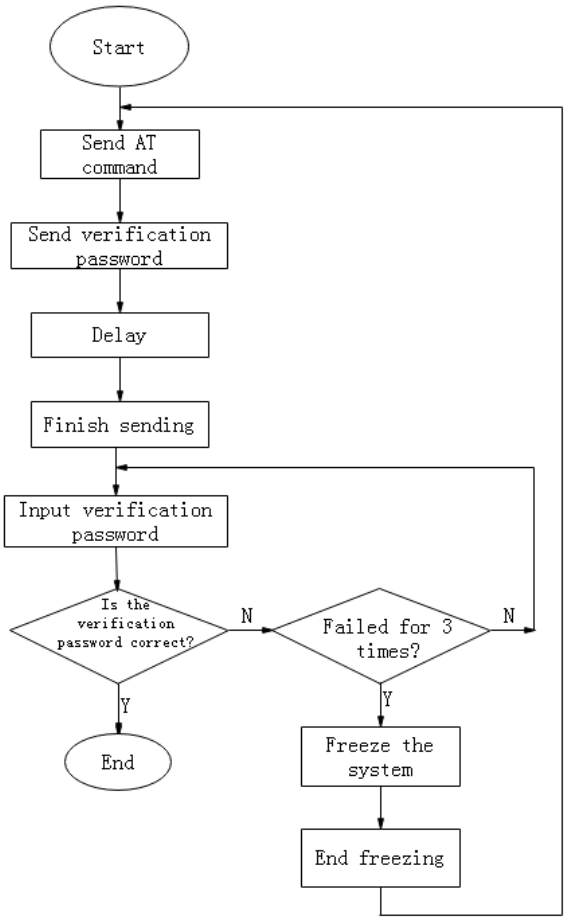

FIGURE VII. FLOW OF MOBILE PHONE VERIFICATION SUBROUTINE

D. Design of Digital Password Change Subroutine

If users need to change digital password of the system, they firstly press the button of "Change Password" on the matrix keyboard. Then, the original password should be input. The new password can be set if the original password is correct, otherwise another original password need to be entered. The system will be frozen after 3 times of input error, accompanied by sound-light alarm. Meanwhile, an alarm message is sent to the user's mobile phone. Figure VIII shows flow of the subroutine of digital password change.

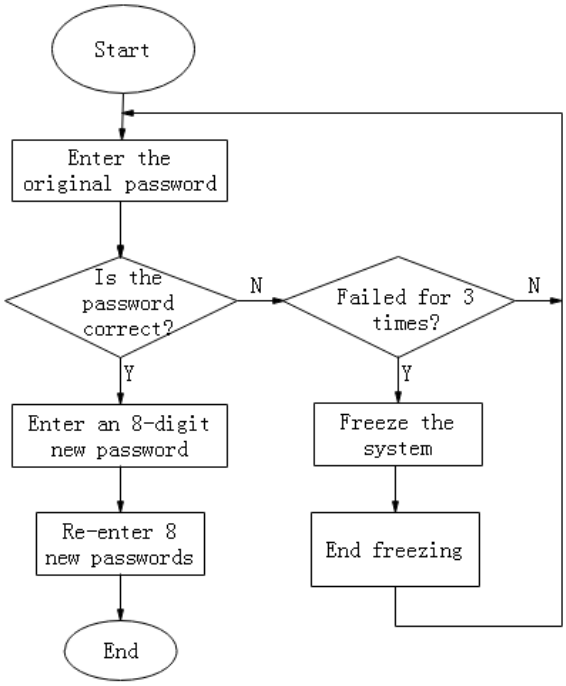

FIGURE VIII. FLOW OF THE SUBROUTINE OF DIGITAL PASSWORD CHANGE

V. SYSTEM TEST

After completing design of the system, we tested each module through programming. A whole test was performed after individual test had been finished. The first step was to set initial password of the system, followed by entering and storing the fingerprint. The overall test was performed after successful setting. Figure IX shows the physical map and display interface of the system.

FIGURE IX. PHYSICAL MAP AND DISPLAY INTERFACE OF THE SYSTEM

Figure IX indicates that the system enters fingerprint capturing interface if correct digital password is input. After the fingerprint is collected and matched, the system sends

verification password to the user's mobile phone. The access control will be opened if the verification password is correctly input. In case of recognition error, the user is prompted to re-enter digital password or fingerprint. However, the system enters the frozen state after 3 times of error, with sound-light alarm. Meanwhile, an alarm message is sent to the user's mobile phone. The test results show that the system can realize triple-password protection functions of digital password, fingerprint identification, mobile phone verification. The system enters the frozen state after the error of digital password or collected fingerprint reaches 3 times. At the same time, the sound-light alarm is performed while an alert message is sent to the user's phone. The test data demonstrates that the system can accommodate 200 fingerprint data. The fingerprint recognition time is less than 0.4 s; rejection rate less than 1%; and false recognition rate less than 0.001%.

VI. Conclusions

Safes have entered ordinary people's houses with economic development and wealth accumulation. The safe access control system with multiple password protection adopts STC12C5A60S2 single-chip microcomputer as the control core. The first protection is realized by comparing traditional digital password. Then, the second protection is achieved by comparing the frontier biometric technology—fingerprint recognition. Finally, the third protection is implemented though GSM module, sending verification password to mobile phone. The triple protections are sequential and indispensable. Moreover, functions of remote monitoring and alarming enhance safety, reliability and significance of safes.

Acknowledgment

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