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Design of Access Control System Based on STM32 and Visible Light Communication

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Abstract. With the development of LED and SCM technology, visible light communication technology has attracted more and more attention. This paper studied the design of access control system of STM32 and visible light communication based on the analysis of the basic principle, principle of light emitting visible light communication LED device, a visible light communication channel model, the access control system of STM32F103 and visible light communication based hardware design in detail, and the software design in in the aspect of hardware, the key to achieve the key transmission, low power consumption in the electric lock function; realizing key acceptance, low power consumption, to achieve the desired purpose.

Keywords: STM32; visible light communication; Entrance guard system; LED

1. Introduction

Variable Light Communication technology [1] uses the high speed modulation response characteristic of the LED lamp, and controls the high speed flicker of the LED lamp by driving current to realize communication. The transmission speed can reach more than 1000 trillion at present. Visible optical communication technology does not occupy spectrum bandwidth, does not exist electromagnetic interference and radiofrequency radiation, green environmental protection, and has the advantages of traditional wireless communication. Optical communication technology has the characteristics of high directivity. It has high security advantage in short distance communication, and information is not easy to be intercepted by malicious. At the same time, it can encode specific optical signals and is not easy to be cracked. In addition, visible light communication equipment is low cost and convenient to use. It is suitable for large-scale popularization and application. As a popular communication technology, it has the advantages of high reliability, good secrecy, no electromagnetic interference and no spectrum authentication [2, 3].

In this paper, a wireless access control system based on STM32 and visible light communication is designed. The system consists of two parts, the light key and the light control lock. Through the optical key to send out the unlocking cipher, the password information is loaded onto the LED light of the light key. Through free space, the information is transmitted to the photoelectric receiver of the photo controlled lock, and the door lock is controlled and closed by comparing information.

2. Channel Analysis Of LED Visible Light Communication System

The visible light communication system can be modeled as a linear system of baseband, as shown in Figure 1, which represents a linear baseband transmission system model for h(t) [4].

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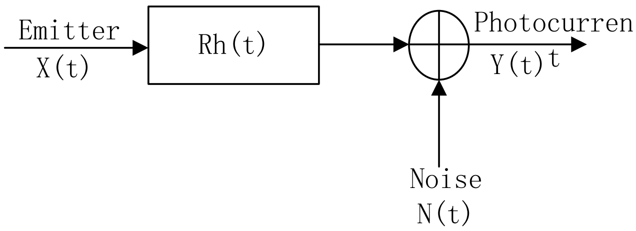

Fig. 1: Linear baseband transmission system model corresponding to h (t) pulse.

Among, X(t) is a modulated signal, R represents the conversion efficiency of LED, h(t) is channel impulse response, It is mainly used to reflect the transmission characteristics of the channel, N(t) is Additive noise in the channel, Y(t) is the photocurrent signal received by the receiver. From the above picture:

$$Y(T) = RX(t) * h(t) + N(t) \tag{1}$$

* represents convolution.

In an ideal situation, the white LED light source of visible light communication system as a Lambertian radiator, The Lambert model can be used to study the LED light source. The DC gain of the channel H(0) can be expressed as:

$$H(0) = \begin{cases} \dfrac{(m+1)A}{2\pi d^2} \cos^m(\phi) T_s(\psi) g(\psi) \cos(\psi), 0 < \psi < \psi_c \\ 0 \qquad\qquad , \quad \psi > \psi_c \end{cases} \tag{2}$$

In the formula, m represents the radiation pattern of the LED light source, A is the detection area of the photodetector, d refers to the distance between the receiver and the transmitter, Φis the angle of light emitted from a light source relative to the light line of the light source, Ts(ψ) refers to the filter gain, ψ refers to the angle of incidence, g(ψ) refers to the gain of optical energy.

Optical fusion gain g(ψ) can be expressed by the following formula:

$$g(\psi) = \begin{cases} \dfrac{n^2}{\sin^2 \psi_c}, 0 \le \psi \le \psi_c \\ 0 \quad , \quad \psi > \psi_c \end{cases} \tag{3}$$

n represents the launch index.

3. System Design

3.1 System overall design

Access control system based on STM32 and visible light communication uses STM32F103 singlechip as the main control chip, Using the principle of serial communication of single chip microcomputer, the optical key module is controlled by the optical key module to realize the opening and closing of the door lock.

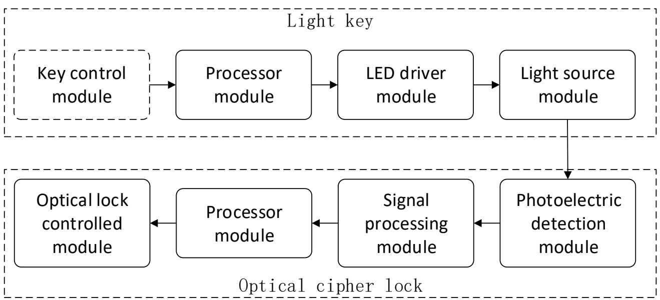

Fig. 2: General block diagram of the system

General block diagram of the system is shown in Figure 2, The optical key module consists of key control module, processor module, LED driver module and light source array module. The optical password lock module consists of the photoelectric detection module, the signal processing module, the processor module and the light lock controlled module. The photoelectric detection module checks and receives the optical signal, processes the optical signal, sends the signal to the processor, and the processor checks and matches the key information, resulting in a controlled signal to control the opening or closing of the optical password lock.

3.2 Hardware design of light key

The optical key module mainly realizes the function of controlling the generation and sending of key information. The optical key module is mainly composed of the processor module, the LED drive module, the key control module and the power module.

3.2.1 Light source selection

This design has chosen OSRAM's white light LED with a bandwidth of about 1.8MHz. The parameter table is shown in Table 1.

Table 1: OSRAM white light LED parameter information table

Power	Luminous flux	Working voltage	Electric current	Reverse voltage	Reverse current	Luminescence angle
3W	90-100lm	3.0-3.6V	300-350mA	5V	5uA	120-140

3.2.2 Design of processor module

The processor module uses the MCU STM32F103 of Italian semiconductor company as the main control core. The chip has a clock frequency up to 72MHZ, and has 16 bit timers and 12C, USART, SPI and other interface modules. It has 512K byte flash memory and 64 K bytes of SRAM, which meets the design requirements of the system [5].

3.2.3 Design of LED driver module

The LED drive circuit is also the direct modulation circuit for the LED. It is necessary to choose the appropriate modulation technology according to the type of the electrical signal [6]. For the design of this paper, we need to use LED to send out the digital pulse signal generated by FPGA processing, so we design the direct modulation circuit of pulse signal to LED as the LED driving circuit in this system.

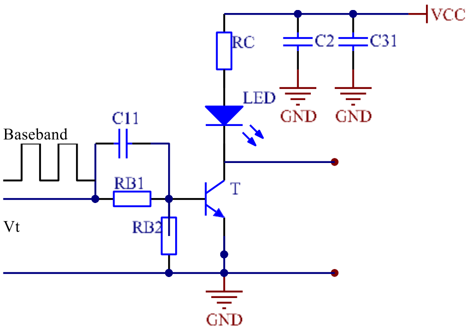

Fig. 3: High power LED drive circuit

3.2.4 Design of key control module

Light key is a transmitter based on single chip STM32F103. In this design, the light key can send different keys and can not only open the door lock by different keys, but can also implement other functions. Therefore, the optical key module in this design is not a simple one to one device, but a one to many devices. It is necessary to use different keys to send different key information in the design of human-computer interaction, and to combine the software with the different functions.

3.3 Hardware design of optical cipher lock

The hardware of optical cipher lock consists of the photoelectric detection module, the signal processing module, the processor module and the light lock controlled module. The main realization of optical signal detection, conversion, amplification and control.

3.3.1 Design of photoelectric detection module

In the optical control lock module, the photoelectric detection module is the key to realize the optical signal to the electrical signal conversion, and its design performance has a great influence on the performance of the prototype system. In this design, use of S6968 photodetector and OPA658 amplifier, as shown in Figure 4. The circuit can effectively detect the weak light signal and can effectively suppress the background noise interference.

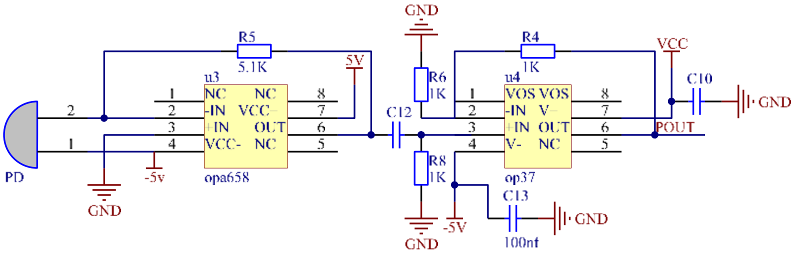

Fig. 4: Photoelectric detection module circuit

3.3.2 Signal processing module

The optical signal is converted into an electrical signal from the optical signal through the photodetector, and then through the amplification of the preamplifier module, the weak signal is transformed into a stronger signal. But these signals are analog signals. To input the signals into the single chip STM32F103 for processing, the analog signals must be converted to digital signals.

3.3.3 Optical lock controlled module

Singlechip P1.1 port for unlocking signal output pin, It is connected to the base of the transistor S2 through a current limiting resistance R2. Diode D1 is a continuous current diode to ensure the stability of the relay. P6 is connected to the positive pole of electronic control lock. When the P1.1 port is low power, electronic lock closure to realize unlocking function. When the P1.1 port is high, the transistor S8550L cutoff, release of electronic control lock and realize lock function.

4. System Software Design

4.1 Optical key software design

Based on the STM32F103 processor chip and the corresponding hardware peripherals, the flowchart of the light key module in this design is shown in Figure 5.

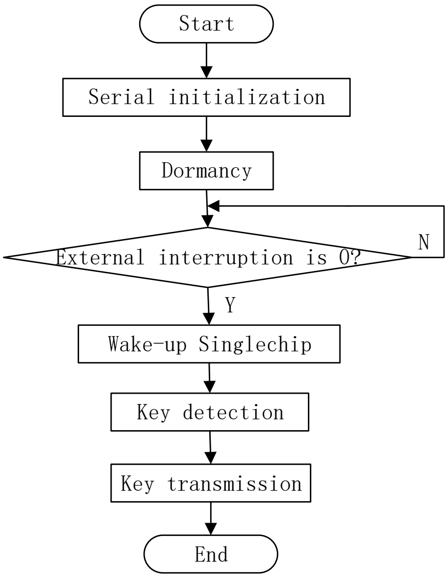

Fig. 5: Adaptive weighted average data fusion algorithm estimation model.

After the light key processor STM32F103 is on power, the initialization setting is first set up. After the setting is completed, it enters the dormancy state and reduces the power consumption. The man-machine interface module is pressed S1, S2 or S3, causing external interruption 0, awakening the single chip microcomputer. The single chip computer determines the specific key through the key detection function.

4.2 Software design of light cipher lock

Based on the STM32F103 processor chip and the corresponding hardware peripherals, The flow chart of the optical cipher lock module in this design is shown in Figure 6.

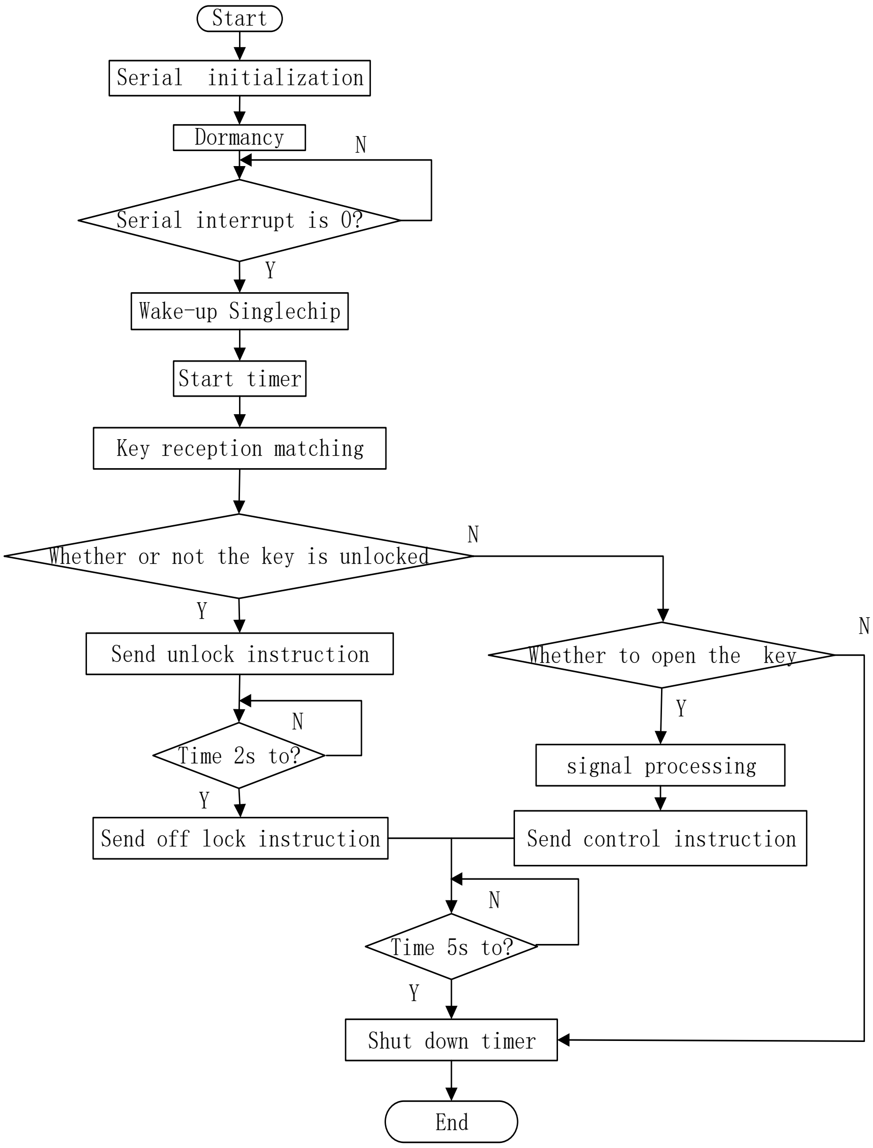

Fig. 6: The flow chart of the optical cipher lock module

First into the initialization, after the related initialization operation, enter the dormancy state, in order to save power. When the RxD(P3.0) pin of the processor STM32F103 of the light control lock receives the information sent from the optical key end, triggering the serial port interruption, the processor STM32F103 is wakeup from the dormancy state. When the detected information is the key to unlock the secret key, unlock the microcontroller to send instructions, open the door to realize. The timer is timed to 2s, and the MCU sends the lock instruction to close the lock. The timer is fixed to 5s, the single chip computer closes the timer, and the single chip computer is back to the dormancy mode. The timer is timed to 5s, the MCU closes the timer, and the MCU returns to sleep mode from wake-up mode to save power. If the detected key information, neither the key nor the key lock lights, MCU directly off timer, enter sleep mode.

5. System Performance Testing And Analysis

After several joint debugging, the design of access control system based on STM32 and visible light communication is completed. When the switch S1 is pressed, the door lock opens and the door lock is closed after 2 seconds. When the switch S2 is pressed, LED1 lights up, again presses the switch S2, and LED1 goes out. When the switch S3 is pressed, LED2 lights up, again presses the switch S3, and LED2 goes out. Through the combination of hardware and software, the pre designed function can be achieved well.

6. Conclusion

With the development of LED and SCM devices, more and more attention has been paid to STM32 and visible light communication technology. Visible light communication is a new way of communication. By loading information into the LED lamp, it sends information in the air through the high speed of the LED lamp. Compared with the traditional wireless access control, the visible light is not subject to electromagnetic interference and is not penetrable, so it has a lot of security. In this paper, on the basis of visible light communication, the development of a access control system is realized.

7. Acknowledgment

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