Scholar Publishing Group
International Journal of Big Data Intelligent Technology
https://doi.org/10.38007/IJBDIT.2024.050101
ISSN 2790-0932 Vol. 5, Issue 1: 1-8

Design of Elevator Light Curtain Monitoring System Based on Internet of Things

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Keywords: Elevator Light Curtain, Monitoring and Control, Internet of Things

Abstract: This paper designs an elevator light curtain monitoring system based on Internet of Things, which is composed of infrared transmitting and receiving module, control module, Bluetooth module and so on. The infrared transmitting and receiving module is used to transmit and receive infrared signals. The control module connects the infrared transmitting and receiving module and the Bluetooth module to receive and process data and perform corresponding actions. The Bluetooth module is used to connect with the mobile phone platform to transmit data and instructions.

1. Introduction

With the development of urbanization, elevator has become an indispensable travel tool in People's Daily life. According to statistics, 80% of elevator safety accidents are because of elevator door accidents, elevator door safety protection is the most important thing to maintain elevator safety. With the development of infrared technology, the infrared elevator light curtain can accurately and quickly detect people and things around the elevator door, and the detection signal is fed back to the door control system. When there is a dangerous situation, the elevator door can be stopped and the safety factor of the elevator door can be improved [1, 2]. In this paper, through the Internet of

Things technology, the elevator light curtain operation data is uploaded to the cloud platform in real time, to realize the remote monitoring of the elevator door by elevator light curtain, and to provide accurate data support for maintenance personnel.

2. Hardware Design of Elevator Light Curtain Monitoring System

2.1 System Hardware Architecture

The hardware structure of the system is shown in Figure 1, which is mainly divided into the following parts:

(1) Infrared emission part: realize the emission of infrared signal.

(2) Infrared receiving part: It is responsible for receiving and analyzing the signal sent by the infrared transmitting tube and output it to the control device [3, 4].

(3) Control device: composed of STM32 and S7-200, it is responsible for processing and transmitting the signal output of the receiving module, and executing the corresponding control operation.

(3) Bluetooth communication module: realize the information communication and interaction between the control module and the cloud platform, transmit data information to the platform, and issue platform instructions to the control module.

(4) Mobile APP: responsible for the display of the operating status of the light curtain, and issue control commands.

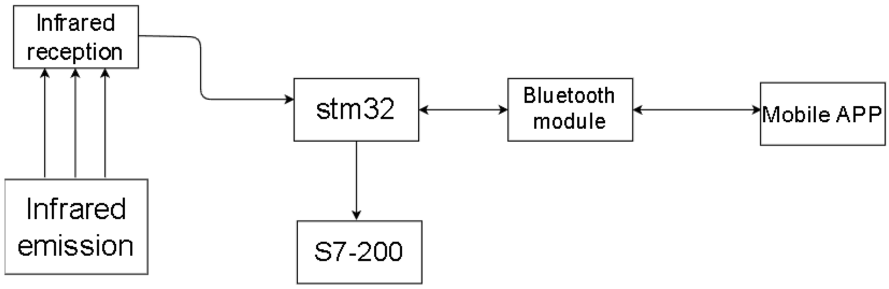

Figure 1. Hardware system block diagram

2.2 Design of Data Acquisition System

(1) Infrared module

The elevator light curtain infrared module includes: infrared emitter and infrared receiving board two parts. The infrared transmitting tube sends out a light beam, and the receiver processes and outputs the light signal. The receiver is mainly composed of infrared monitoring, demodulation, filtering circuit, etc. This design uses the HX1838 infrared wireless suite, as shown in Figure 2.

Figure 2. Infrared transmitting and receiving suite

The HX1838 infrared receiver can scan, track, range and image acquisition for moving targets, and the carrier frequency is 38kHz.

(2) STM 32F103C8T6 module

STM 32F103C8T6 collects the signal sent from the receiver, determines whether there is any occlusion through processing, and transmits the collected data information, starts timing when the receiver does not receive the infrared signal, and issues an early warning message beyond the predetermined time. STM 32F103C8T6 is a high-performance, low-power ARM Cortex-M3 core microcontroller with a voltage of 2V~3.6V and an operating temperature is -40℃ ~ 85℃. It can support multiple interfaces such as CAN, I^2C, USART, SPI, etc., making it is an ideal choice for industrial control, Internet of Things and other applications [5-7].

The main performance characteristics of STM32F103C8T6 microcontroller are shown in Table 1, and Figure 3 is the pin diagram of STM 32F103C8T6.

Table 1. Main characteristics of STM 32F103C8T6

Fast processing power	The Cortex-M3 core has a main frequency of up to 72MHz and can reach 1.25DMips/MHz on 0-wait cycle access of memory, which is capable of handling complex control tasks quickly.
Strong peripheral support	Powerful peripheral support: STM32F103C8T6 has up to 9 communication interfaces, including *ADC*, *DAC*, I^2C, *SPI*, *USART* and other commonly used peripherals, to meet the variety of application needs.
Strong scalability	STM32F103C8T6 provides the expansion interface, can expand more peripherals or access external memory.
Low power consumption	The STM32F103C8T6 offers a variety of low power modes in sleep, downtime and standby to reduce power consumption while maintaining performance.
Up to 80 fast I/O ports	It is up to 26/37/51/80 I/O interfaces, all mapped to 16 external interrupt vectors, and almost all support 5V debug mode.
Up to 7 timers	3 set 16-bit timers, 2 set Watchdog timers (freestanding and window type) system time timers, 24-bit self-decrement type counter, a 16-bit with dead zone control and emergency brake.

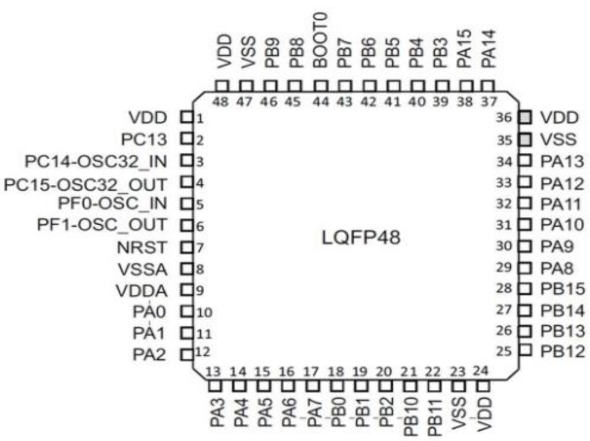

Figure 3. STM32 pin diagram

(3) S7-200PLC controller

Siemens PLC S7-200 controller is mainly responsible for detecting infrared signal, judging and controlling the opening and closing relay, so as to control the opening or closing of the elevator door, and realize the signal transmission with STM32 through the RS485 interface. Siemens S7-200 is a small programmable controller, integrated 14 input /10 output a total of 24 digital I/O points, 2 input /1 output a total of 3 analog I/O points, can connect 7 expansion modules maximum expansion value to 168 digital I/O points or 38 analog I/O points, can meet the requirements of this design. In addition, S7-200 PLC has perfect communication function, can communicate with other PLC, frequency converter, sensor, switching module and various peripheral equipment. Various automatic control functions can be realized through standard communication protocols, such as PROFIBUS-DP, MODBUS and so on. S7-200 series PLC adopts MODBUS protocol and MODBUS industrial Ethernet for data transmission, can realize data exchange, and through Ethernet and industrial control network connected, can upload the data to the top computer management software, can also download the data to the host computer management software. Figure 4 is the physical picture of S7-200.

Figure 4. Actual picture of S7-200

(3) Data communication and Internet of Things system design

This design uses Bluetooth technology to realize the remote communication data interaction between SMT32 MCU and mobile APP. The Bluetooth module adopts JDY-31, which has the advantages of low cost, small size, fast transceiver speed, etc. It only needs to be equipped with a small number of external devices to achieve many functions [8-10]. The physical demonstration of this module is shown in Figure 5 and Figure 6. In Figure 5, front box 1 is the antenna part of the Bluetooth module, box 2 is the integrated control center of the Bluetooth module, and box 3 is its control pin. The back side mainly marks the driving level of the module between 3.6V ~ 6V. The corresponding functions of the pins include RXD serial input, TXD serial output, GND and VCC.

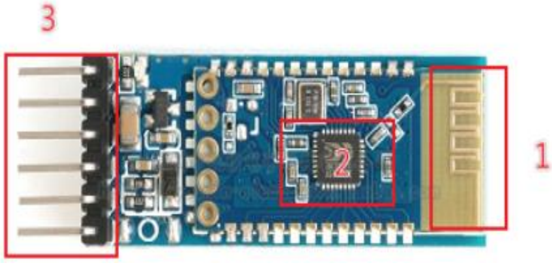

Figure 5. Front view of Bluetooth module

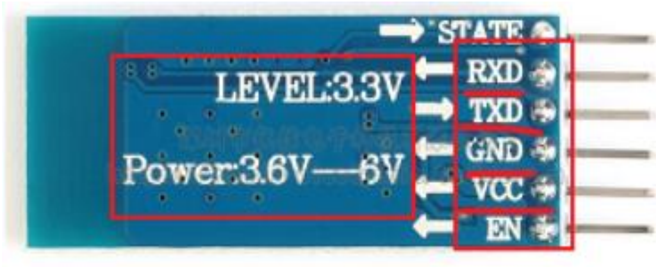

Figure 6. Reverse picture of Bluetooth module

The remote communication between MCU and mobile APP is realized through JDY-31 Bluetooth module. This communication follows UART communication protocol. The connection mode is that RXD of Bluetooth is connected to TXD of MCU. The mobile phone comes with Bluetooth, and the Bluetooth module is connected and paired with the mobile phone APP. The Bluetooth debugger APP is selected as the mobile phone platform. The software supports high frequency real-time data transmission, supports custom control layout and horizontal and vertical screen direction, and quickly completes some system tests. The single chip microcomputer processes the input information of the infrared receiving module and transmits the operation information of the light curtain to the mobile phone APP through Bluetooth. At the same time, the mobile phone APP sends instructions to the single chip microcomputer to control the input of the infrared receiving information. The overall communication architecture is shown in Figure 7.

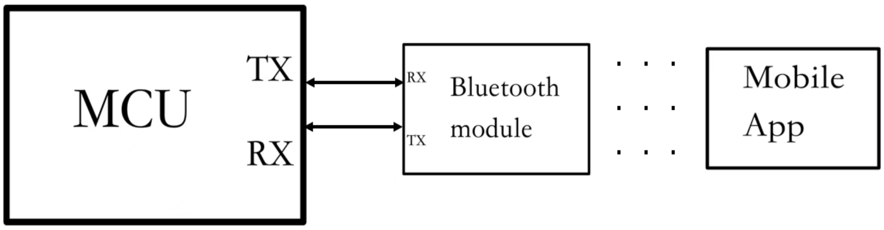

Figure 7. Schematic diagram of communication architecture

JDY-31 Bluetooth module serial port AT instruction set is see table 2.

Table 2. AT instruction set

Serial number	Instructions	Features	Default
1	AT+VERSION	Query version number	JDY - 31 - V1.2
2	AT+RESET	Soft reset	
3	AT+DISC	Disconnect (valid when connected)	
4	AT+LADDR	Module MAC address	
5	AT+PIN	Connect password with settings query	1234
6	AT+BAUD	Baud rate settings and queries	9600
7	AT+NAME	Broadcast name setup and query	JDY-31-SPP
8	AT+DEFAULT	Factory data reset	
9	AT+ENLOG	Serial port status output enabled	1

3. Software Design of Elevator Light Curtain Control System

This design uses C language to write software program. The system is initialized after powering on, each sensor device is initialized, the infrared receiving module receives data, the MCU judges the normal running status or the fault, the running status information is sent to the mobile phone through the Bluetooth module. The mobile phone sends stop or start commands to control the reception of infrared signals. The overall flow chart of the software is shown in Figure 8.

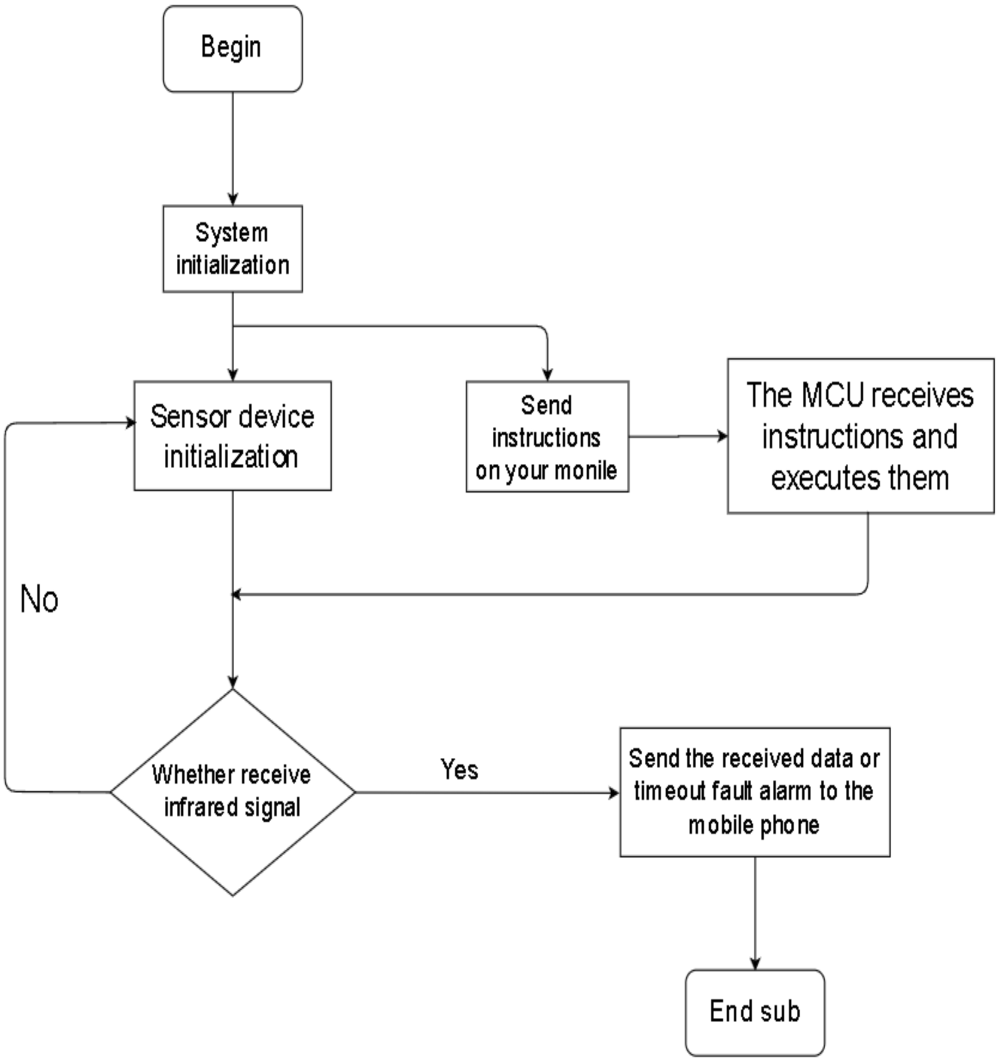

Figure 8. Software overall block diagram

4. System Debugging and Operation

The overall hardware device has been assembled. The infrared module and Bluetooth module are connected with the control module by connecting cables and are fixed on the same circuit board [11]. Turn on the power supply and observe whether each device can run. After observation, each device can run normally and stably. Open the Bluetooth Debugging Assistant APP, search for the designed JDY-31 Bluetooth module, click "connect", it will display whether the Bluetooth module and APP are successfully paired and connected.

Test the function of the system, there is no block between the infrared emission and the infrared receiving board, so that the infrared receiving board can normally receive infrared information, the mobile phone APP should be displayed as OK. After running the device, the experimental result is consistent with the expectation, and the display interface of the mobile phone software displays "OK" character.

An object is used to block the infrared transmitting board from the receiving board, so that the transmitting board cannot receive the infrared signal. If the setting exceeds 10 seconds, the mobile phone platform should show "err" for fault alarm.

The mobile phone end sends stop to stop the collection of infrared signals, and then displays err characters in the mobile phone APP. Send start to restart the collection of infrared signal, and the mobile phone APP will display the character “OK” again.

After debugging of each function, the test results are in line with the expected requirements.

5. Summary

This paper designs the hardware and software of elevator light curtain control system based on Internet of Things, carries out system debugging and running test, and the test results reach the expected goal.

Funding

This paper is supported by Projects of major scientific and technological research of Ningbo City (2020Z065, 2021Z059,2022Z090(2022z050), 2023Z050(the second batch)), Major instrument special projects of the ministry of science and technology of China(2018YFF01013200), Projects of major scientific and technological research of Beilun District, Ningbo City(2021BLG002, 2022G009), Projects of engineering research center of Ningbo City (Yinzhou District Development and Reform Bureau [2022] 23), Projects of scientific and technological research of colleges student's of China(202313022036).

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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