Smart lighting system based on Bluetooth

Chenwei Feng*, Xianling Wang, Zhuo Li, Weiming Lin, Huazhi Ji and Shaomin Shen
School of Opto-electronic and Communication Engineering, Xiamen University of Technology, Xiamen, China

*Corresponding author. Email: chevyphone@163.com

Abstract. A smart lighting system uses the concept of green, low-carbon, energy-saving and environmental protection to change people's lifestyle and bring about high-quality life. This paper designs a smart lighting control system based on Bluetooth and Android. When the system is in automatic mode, the pyroelectric infrared sensor can be used to detect whether anyone is passing by to control the LED light on or off. The LED light can be also controlled by the Android app through Bluetooth communication when the system is in manual mode. The testing results show that the system is energy-saving, efficient and easy-to-use, and it can be widely used in various lighting scenes.

1. Introduction
In recent years, people's demand for intelligent and high-quality life is increasingly strong, and the requirements for lighting are also increasing. The wiring of traditional lighting system is cumbersome, management expansion is poor, and the lighting effect is single. Based on the technologies of Internet of things and wireless communication, a smart lighting system is necessarily developed to meet the current social needs. There are many common wireless communication technologies such as Bluetooth, Wi-Fi, ZigBee and so on. Bluetooth is widely used in fields of energy management system, smart lighting control system and home automation due to its low cost, low power consumption and ease of use [1-3]. This paper uses an STC89C52RC as the core controller, combined with a pyroelectric infrared sensor, to achieve a smart lighting control system based on Bluetooth and Android. The testing results show that the system has the advantages of low cost, low power consumption, stable operation and easy expansion, which can be widely used in various lighting scenes.

2. System overall scheme
The overall design scheme of the smart lighting system is shown in Fig. 1. The system consists of a Microprogrammed Control Unit (MCU) minimum system, a pyroelectric infrared sensor module, a Bluetooth module, a mode indicator, an LED module and a power module. In automatic mode, the pyroelectric infrared sensor module will output a high level signal if someone is passing by. According to the feedback high level signal from the pyroelectric infrared sensor module, the MCU gives a command to turn on the LED, which is turned off after a period of time. In manual mode, the communication between the smart phone and MCU can be realized through the Bluetooth module. With the operation of Android application in smart phone, the LED can be turned on/off and its brightness can also be adjusted. The mode indicator is used to indicate the current working mode. The power module provides power for the whole system.
3. System hardware design

3.1. MCU minimum system
The STC series MCU is low-cost, easy-to-use and relatively simple to operate. The minimum system circuit of STC89C52 includes the crystal oscillator with 11.0592MHz, reset circuit and MCU. The reset circuit consists of a capacitor in series and a resistor. When the system is powered on, the RST pin of MCU generates a high level [4].

3.2. Pyroelectric infrared sensor module
The pyroelectric infrared sensor module is mainly based on HC-SR501, which has the characteristics of a large sensing range and strong sensitivity[5]. HC-SR501 is an automatic control module based on infrared technology with two detection modes of single detection and continuous detection. The continuous detection mode is adopted in this system. When the sensor detects that someone is passing by, a high level is output and the LED is turned on till he/she leaves the detection range of the sensor. The circuit of the pyroelectric infrared sensor module is shown in Fig. 2, where pin 3 is connected to the power supply VCC, pin 1 is connected to ground, and pin 2 is connected to pin P1.1 of MCU as the output port.

3.3. LED module
The LED with USB interface is selected and the Pulse Width Modulation (PWM) is used to control the brightness of the LED in the scheme[6]. The current changes with the change of duty cycle, so the brightness of LED changes. In order to prevent the LED from being damaged, the PNP type triode of S8550 is adopted. The base of the triode is connected to pin P1.1 of MCU to transmit the signal of dimming, as shown in Fig. 3.
3.4. Bluetooth module
The Bluetooth module is mainly responsible for the wireless communication between the smart phone and MCU. The Bluetooth module based on JDY-31 is selected in the scheme, and the module works at 2.4GHz. The maximum transmitting power is 8dBm, and the maximum transmitting distance is 30m. Users can modify the device name and baud rate through AT command, which is convenient and flexible. The Bluetooth module circuit is shown in Fig. 4, where pin TXD is connected to pin RXD of MCU, and pin RXD can be suspended[7].

![Figure 4. Bluetooth module circuit.](image)

3.5. Mode indicator
The function of the mode indicator is to let the user know what mode the system is working in currently. The circuit of the mode indicator is shown in Figure 5. The circuit is composed of an LED and a voltage divider resistance with value of 1K. The negative pole of the LED is connected to pin P2.0 of MCU.

![Figure 5. Mode indicator circuit.](image)

3.6. Power supply module
The power supply module circuit uses a common power socket to provide a DC power of 5V, which can be powered by the USB interface of PC or the plug of smart phone charger.

4. System program design

4.1. System overall program design
The overall program design flow of the system is shown in Fig. 6. Firstly, the system is initialized, and then judges whether the MCU receives a command sent by the Android smart phone app. According to the received command, the corresponding operation is executed. If the system is in automatic mode, the mode indicator will light on. Subsequently the system will detect whether anyone is passing by according to the signal sent by the pyroelectric infrared sensor. When someone is passing by, the system turns on the LED. If he/she beyond the detection range, the system will turn off the LED after 10 seconds.
4.2. PWM dimming program design

The principle of PWM dimming is to determine a fixed time period firstly, which is 10 ms in this design. In this cycle, different ratios of high-level and low-level are determined, so different levels of LED brightness is determined. The flow chart of PWM dimming program is shown in Fig. 7.

4.3. Android smart phone app design

Android smart phone app is created and developed through E4A [8]. The visual operation interface of the app is shown in Fig. 8. In this design, there are eight button components, an advanced list box component and an invisible class library. After clicking "search", if the Bluetooth module is found, the Bluetooth module name will be displayed in the blank list box. When a button is pressed, the app will
send the corresponding value such as a, b, c, d, e and f to the JDY-31 Bluetooth module. The LED will be operated by the command received according to Fig. 6.

5. Test and analysis
After the Bluetooth of the smart phone and the Bluetooth module of the lower computer are matched successfully, the default mode of manual mode is set. When the "On" button in the app is clicked, the MCU module will turn on the LED once receives the command; when the "Off" button is clicked, the MCU module will turn off the LED. When the "Light +" button is clicked, the MCU will increase the brightness as shown in Fig. 9; when the "Light -" button is clicked, the brightness will be dimmed as shown in Fig. 10. After many tests, it is found that the smart lighting system can be controlled quickly and correctly within 10 meters.

![Figure 9. Brightness increase.](image1)

![Figure 10. Brightness reduction.](image2)

By clicking the "Auto Mode" button, the system will switch to automatic mode, and the mode indicator will light up. After many tests, it is found that when someone is within an average distance of 3.5m in each direction of the infrared sensor module, the LED can be automatically turned on.

6. Conclusions
This paper designs a smart lighting control system based on Bluetooth and Android. The system is mainly composed of an MCU control module, LED module, pyroelectric infrared sensor module, Bluetooth module and smart phone app. The system realizes the functions of remote manual control and automatic control of the LED. The testing results show that the system is easy-to-use, stable, low cost, and has good expansibility and market application.

Acknowledgements
This work was supported by National Science Foundation of China (Grant No. 61801412), High-level Talent Project of Xiamen University of Technology (Grant No. YKJ17021R, and No. YKJ20013R), Scientific Research Climbing Project of Xiamen University of Technology (Grant No. XPDKT19006), and Education and Scientific Research of Young Teacher of Fujian province (Grant No. JT180458, No. JT180430, No. JAT190677, No. JAT200471, and No. JAT200479).

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