Design and Implementation of Wireless Communication System Based on CC1100

Jianhua Gao¹, Yuanjing Zhu²,*

¹Center for Practice Innovations, Huazhong University of Science and Technology, Wuhan 430074, China
²Yunnan Minzu University, Kunming 650504, China

*Corresponding author e-mail: 1018761837@qq.com

Abstract. As one of the most promising information technologies in this century, radio frequency technology has been highly valued. The technology utilizes the radio frequency method for non-contact two-way communication, it can automatically identify the target object and acquire relevant data, and it has many advantages such as high precision, strong adaptability to the environment, strong anti-interference ability, and fast operation. The radio remote control uses radio frequency signals to control remote devices of remote control devices. For modern homes, various home appliances are designed to control multiple devices and wireless remote control switches. This paper designs a simple wireless remote control system based on CC1101 communication module. Based on the theory of wireless transceiver technology, the system realizes the transceiver and status display of wireless data.

1. Project Overview

1.1. wireless switch introduction

The traditional switch controls the electrical target by controlling the on-off of the strong electricity directly. Because the mechanical switch is easy to wipe out the spark that may lead short circuit, it needs frequent maintenance, and it is difficult to control in a relatively large space. In order to adapt to the development of the times, the wireless switch also appears in our life [1], and the wireless switch has features such as no wiring and strong mobility, easy to control, safer, and generally not easily damaged. Wireless switches break through space constraints and make our lives easier.

1.2. Design requirements

The multi-channel wireless remote control switch designed by us selects the RF communication chip CC1101 for design (as shown in Figure 1), the working frequency is 433 MHZ, and the remote control distance is more than 10 m. It can be applied to lighting control of homes, offices, shopping malls, hotels, hospitals, warehouses and other places, as well as remote control of partition control, such as living room lighting that can be remotely controlled in a room.

Requirements and data:
(1) Working frequency 433MHz;
(2) The number of remote control roads is not less than 8;
(3) The remote control distance is above 10m;
(4) Controlled objects: lamps, household appliances.

![Figure 1. CC1101 chip physical image](image.png)

### 1.3. Design content and program demonstration

The device is composed of a processing unit, a transmitting and receiving module, an external circuit. When the transmitting module sends a signal, the corresponding switch of the receiving module performs the corresponding operation, and the LED state is turned on to display the switch state.

1. **Processing unit:**
   After comparing the performance indexes of the Single-Chip Microcomputer 51 Series and C8051 Series, the C8051F310 Single-Chip Microcomputer with a better compatibility and stable performance is selected as the processing unit [2-3]. The operating voltage of this Single-Chip Microcomputer system is between 2.7V and 3.6V.

2. **Transmitting and receiving devices:**
   The wireless transceiver unit selects the CC1101 radio frequency chip. The CC1101 is connected to the microcontroller using the SPI interface. The chip size is small, the power consumption is low, and the data rate supports 1.2 ~ 500 KBPS programmable control. It can work in four bands of 915 MHz, 868 MHz, 433 MHz, 315 MHz, and the frequency provides 10 - 30 ~ dBm output power. In this paper, the frequency of CC1101 433 MHz adopts frequency-shift keying modulation method, the data rate is 100 KBPS, and the channel spacing is 200 kHz.

### 2. Design of CC1101 communication module

#### 2.1. Introduction to CC1101 Module

The chip was developed by CC1101 Chipcon based on SmartRF technology. It has the features of low power consumption, low voltage, small size and high sensitivity. A simplified block diagram of the internal structure of the CC1101 monolithic integrated circuit is shown in Figure 2.
The CC1101 MCU and some external components can form a complete wireless data transceiver system. As shown in Figure 2.5, the wireless remote control switch designed in this paper uses the MCU to control the P2 port of CC1101 and data transmission. Figure 2.6 is a schematic diagram of the circuit based on the CC1101 wireless communication module. A triode is added to the power supply terminal of CC1101 to control the connection between CC1101 and the power supply. When P3.5 outputs a high level, the triode is turned off, CC1101 is disconnected from the power supply; when P3.5 outputs a low level, the triode is turned on, CC1101 is connected.

2.2. RF circuit PCB design based on CC1101

(1) Layout design of wireless communication module PCB

It must be consider the layout of the components for CC1101 PCB design, as shown in Figure 3.9. To make the input end of the RF circuit away from the output end, we separate the strong electric signal from the weak electric signal[4-5], and separate the digital signal circuit from the analog signal circuit, and the circuit that performs the same function should be arranged within a certain range, thereby reducing the signal loop area. The filter network of some circuits should be connected nearby. This not only reduces radiation, but also reduces interference and improves the anti-interference ability of the circuit.

(2) Anti-jamming design of the digital part of the wireless remote control switch to the RF circuit

Digital circuits and RF circuits can work independently and well. However, if you put the two on the same board and work with the same power supply, it will cause the system to be unstable. The main reason is that digital signals oscillate frequently between (0 v) and power (5 v), and the period is very short, usually one nanosecond or microsecond. Due to the large amplitude and short switching time, the digital signal contains a large number of high frequency components which is independent of the switching frequency. If you can't separate the digital signal from the RF signal, weak RF signals can be destroyed, so the performance of wireless devices will deteriorate or not work at all.

(3) Anti-jamming design of the power supply part to the RF circuit

RF circuits are very sensitive to power supply noise, especially for glitch and other high frequency harmonic voltages. There is noise after the voltage output of the booster chip MAX856. The MCU and other power-consuming chips will suddenly inhale most of the current in a short period of time within each internal clock cycle. If the power supply is not decoupled at the power supply end of CC1101, it
will cause voltage glitch on the power line. When these voltage glitch reach the power supply pin of the RF part, it will affect the wireless part. In severe cases, the wireless communication may fail.

In order to solve the interference of the power supply to the circuit, this article has two aspects: First, the power star wiring method is used, as shown in the following figure. Each module on the board have its own power line from a common power supply point. In this case, the star line means that the digital part of the circuit and the RF circuit use their respective power lines to reduce the interference of the power supply of each part. The second is to add decoupling and bypass capacitors near the power input, as shown in the figure below. 47 u F decoupling capacitors and 3 bypass capacitors are added to the terminal power supply of CC1101. Decoupling capacitors can effectively eliminate the coupling effect between circuits, and bypass capacitors can eliminate high frequency noise. Decoupling and bypass capacitors are also added to the terminal power supply of the MCU power supply and other chips to reduce the effects of power supply noise (as shown in Figure 3).

![Figure 3. Schematic diagram of the power supply filter circuit of the wireless communication module](image)

3. **CC1101 wireless transceiver design and implementation**

By configuring the CC1101 correctly, wireless transmission of data can be achieved. The wireless communication module receives the wireless feedback control command, and then performs operations such as resetting, packing, and data packet transmission according to the wireless remote control switch. The wireless transceiver process is as shown in Figure 4.

The sequence of operations for program reset is as follows:
1. Set SCLK=1 and SI=0 to avoid potential problems caused by pin control mode;
2. Set CSn to low and then pull it high again;
3. keeping CSn at least 40μs high;
4. Pull CSn low and wait for SO to go low (CHIP_RDYn);
5. Send the SRES command on the SI;
6. When the SO goes low again, the reset operation is completed and CC1101 is in the IDLE state.
3.1. Communication distance test

Communication distance and power consumption are two important performance parameters of wireless communication module. According to the design of this paper, the CC1101 wireless communication module is built and the actual test of two important performance parameters is carried out. The experimental results show that the wireless communication module designed in this paper fully meets the system requirements.

(1) Communication distance test

Firstly, the wireless communication distance in free space propagation is theoretically calculated. The so-called free space propagation refers to the propagation of electric waves around an infinite vacuum around the antenna, which is an ideal propagation condition. When a wave propagates in free space, its energy is neither absorbed by the obstacle nor reflected [6]. The communication distance is related to the transmission power, the receiving sensitivity, and the operating frequency.

The loss of radio wave propagation in free space is

\[ [L_{fs}](dB) = 32 \cdot 44 + 201g(d) + 201g(f)(MHz) \] \hspace{1cm} (1)

\((L_{fs})\) is the transmission loss, \(d\) is the transmission distance, and \(f\) is the operating frequency. When the wireless communication module operates at a frequency of 433 MHZ, a transmit power of 0 DBM (1 mw), and data transfer rate of receiver sensitivity - 93dBm (when 250 KBPS) calculates the propagation distance of free space.

The transmission power is 0dBm and the receiving sensitivity is -93dBm. Then the transmission loss is

\[ [L_{fs}] = 0dBm - (-93dBm) = 93dB \] \hspace{1cm} (2)

Substituting \(L_{fs}=93dB\), \(f=433MHz\) into (3.1),
\[ 93(dB) = 32 \cdot 44 + 2 \lg d(km) + 20 \lg 433.00(MHz) \]  

(3)

Calculated the transmission distance \( d = 2.4 \text{km} \).

This is the transmission distance under ideal conditions. In practical applications, because wireless communication is affected by various external factors, such as the atmosphere, obstacles, multipath effects, etc., the loss caused by these uncertain factors will make the communication distance greatly different from the theoretically calculated transmission distance. In addition, in practical applications, the communication distance that a wireless device can reach is largely related to the selection of the antenna. The communication distance of the wireless communication module is tested by a wireless remote control switch controller and a wireless remote control switch receiver. By programming the wireless remote control switch controller to transmit data, the wireless remote control switch receiver receives the data and displays it through the serial port debugging assistant software, and gradually increases the transmission distance until no data is received. Under the condition that the wireless communication module operates at 433MHz, the transmission power is 0dBm (1mW), and the wireless data transmission rate is 250kbps, after many tests, the communication distance of the wireless module produced in this paper is about 30 meters in the outdoor open space; In the indoor laboratory, the wireless module produced in this paper has a communication distance of about 20 meters. Through testing, it is found that the communication distance of the wireless communication module does not reach the theoretical transmission distance, but such an effect can basically satisfy the use of the design. The CC1101 is reconfigured in software to increase the transmit power and reduce the wireless data transfer rate to achieve a longer communication distance.

(2) Power consumption of the wireless communication module

This paper is designed to test the power consumption based on the CC1101 wireless communication module. The theoretical power consumption is shown in Table 3-1. It can be seen from the table that the ideal operating frequency has little effect on the receiving mode, and it has a large influence on the transmitting mode. The lower the operating frequency, the lower the power consumption, so it can reduce the consumption of the wireless remote control switch when select a lower operating frequency. From the power consumption and transmission distance, the operating frequency should be 315 MHZ or 433 MHZ, but considering the effect of the operating frequency on the antenna, the lower the operating frequency, the longer the antenna. Considering these three factors, the final selected operating frequency is 433 MHZ (as shown in Figure 5).

### Table 1. Theoretical power consumption of wireless communication module

| Working frequency (MHz) | Transmit power (dBm) | Tx theoretical value (mA) | Rx theoretical value (mA) |
|------------------------|----------------------|---------------------------|---------------------------|
| 315                    | +10                  | 27.0                      | 14.5                      |
|                        | 0                    | 14.8                      | 14.5                      |
| 433                    | +10                  | 28.9                      | 15.2                      |
|                        | 0                    | 15.5                      | 15.2                      |
| 868                    | +10                  | 30.7                      | 15.1                      |
|                        | 0                    | 16.9                      | 15.1                      |
| 915                    | +10                  | 30.7                      | 15.1                      |
|                        | 0                    | 16.7                      | 15.1                      |

4. Conclusion

In summary, more and more researchers have conducted research on the anti-interference of electronic circuits, and they have summarized the suppression methods of electronic circuit interference phenomena for different reasons. Combined use of RF-insensitive amplifiers and optimized circuit layouts ensures that RF noise interference is eliminated, even in the harshest environments.
Acknowledgments
This work was financially supported by the Science Research Fund of Yunnan Provincial Department of Education, China (Project Number:2019J0827,2017ZZX325) and The first batch of the Ministry of Education Industry-University Cooperation and Education Project in 2018, China (Project Number: 201801037032, 201801037101).

References
[1] Xiaolei Zhong, Ze Chen. Inter-network crosstalk and communication solution of Zigbee ad hoc network [J]. Optical Communication Research, 2017(4): 70-73.
[2] Ziqin Zhao. Application of Big Data Technology in Intelligent Planning and Decision Platform of Distribution Network [J]. Automation & Instrumentation, 2018(5):78–79.
[3] Hang Su, Xue Xiao. Research on Intelligent Control Technology Mode and Application Prospect of LED Street Lights [J]. China Management Informationization, 2018, 21 (18): 165-167.
[4] Deshi Yang. Research and design of single firewire intelligent switch [D]. Nanjing: Southeast University, 2016.
[5] Xiaolei Zhong, Yao Ru, Research on Scalable Zigbee Wireless Sensor Network Expansion Solution[J]. IOP Conference Series: Materials Science and Engineering, 2018(394/3/032071):1-9.
[6] Liu Qing, Li Yuxiang, Wang Quying, etc. ZigBee high-capacity Mesh networking technology research [J]. Electrical Applications, 2015, (s2): 704 – 707.