Design of Power Line Carrier Communication System based on FSK-KQ330 Module

Yin QUN, Zhang JIANBO (corresponding author)*

Abstract

The power line carrier communication system is designed based on a FSK-KQ330 (carrier modulation and demodulation module). The system uses STC microcontroller as the core processor and uses FSK-KQ330 as the modem module. The system includes the zero-crossing detecting circuit, the magnifying circuit of triodes, the resonant circuit and the transformer isolation circuit. Master-slave system can transmit data signals over power lines. It not only can apply to intelligent home system, but also can be used for the remote control of the intelligent switch and the intelligent equipment.

Keywords: FSK-KQ330, power line carrier communication, STC microcontroller

1. Introduction

The power line carrier communication (PLC) is a specific communication way of the power systems. Power line carrier communication refers to the technology which uses the existing power lines to transmit analog or digital signal by way of carrier at high speeds [1]. The biggest feature is that the system does not need to rebuild the network,and as long as there is wire,data transmission can be performed [2].

The current application areas are mainly concentrated in the intelligent home, intelligent utilities (such as remote meter reading system, street lighting remote monitoring systems, etc.) and industrial intelligence (such as various types of devices data acquisition). Technically, power line carrier communication is no longer a point-to-point communications category, but rather to highlight the concept of open network structure. Each control node (controlled device) forms a centralized network[3]. The system uses the existing power lines network, without rearranging network cable, which helps to save financial, material and human resources[4].At the same time,It is reliable and it is easy to be implemented and be extended[5]. Therefore,there is the significance for the research of the power line carrier system.

Currently, there are three types of international major modulation technology which the high-speed power line carrier communication uses.They are three categories: single-carrier class, spread spectrum class, and OFDM(Orthogonal Frequency Division Multiplexing[6].).The paper analyzed and studied that the FSK single-carrier class is in the application of the electric power carrier communication[7].

2. Structure of the system

The system includes the STC microcontroller (the core processor), FSK-KQ330 module (a modem module), the data transmitting circuit, the data receiving circuit, the zero-crossing detecting circuit, the magnifying circuit of triodes, the resonant circuit and the transformer isolation circuit. Master-slave system can transmit data signals over power lines to achieve the remote control of the host machine. The core of the system includes two parts: one is that STC microcontroller controls the power line carrier module FSK-KQ330 module to send and receive data; the other is that Power line carrier part is composed of power line carrier module FSK-KQ330 and peripheral circuit (resonance detection circuit and amplifier circuit) [9].

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2.1. Overall system design diagram

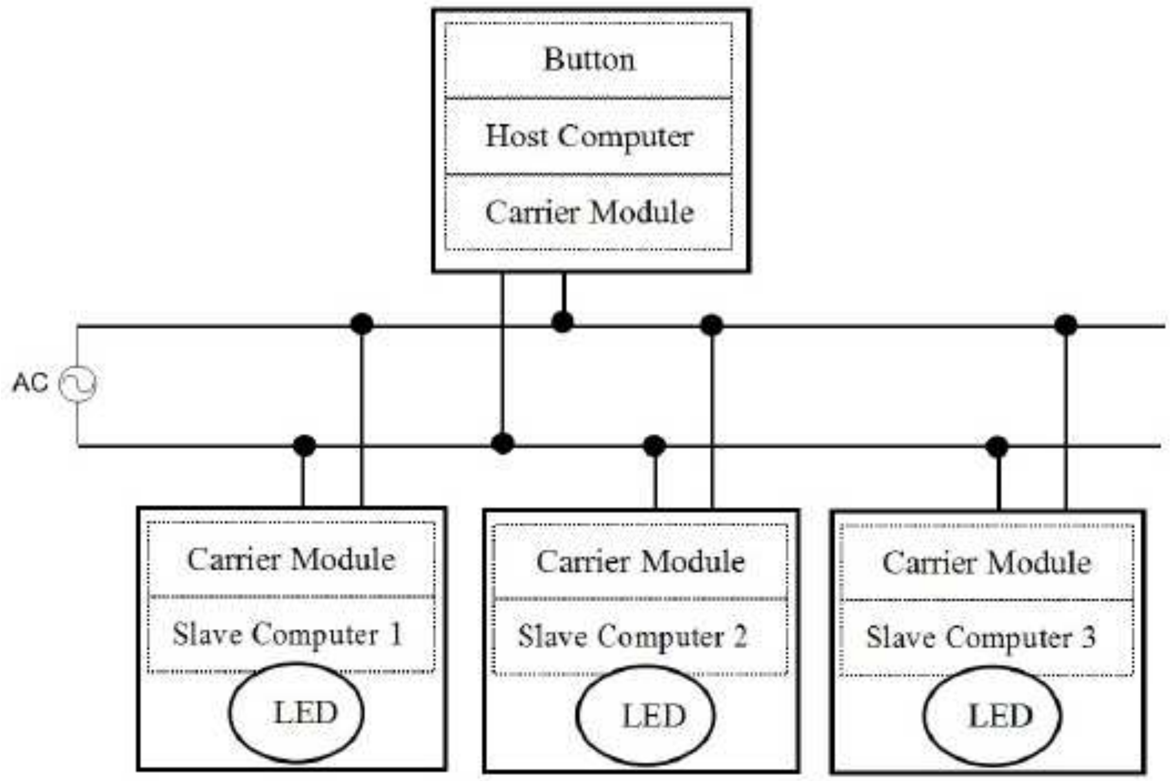

Figure 1. Overall system design diagram

2.2. The overall design concept of power line carrier communication system

The design of power line carrier communication system can be divided into data transmission and data reception according to the data flow [10].

Data transmission flow is as follows: firstly, the system uses the direct interface (serial asynchronous communication) of SCM and FSK-KQ330 module; secondly, after the transmission data is modulated by FSK-KQ330 module, through the external circuit (amplifier circuit and the resonance detection circuit), the square-wave signal changes into the sinusoidal signal; finally, after isolating the interfering signal, the signal is coupled to the power line [11].

The flow of data received is as follows: firstly, the resonance detection circuit detects the received signal; secondly, after the signal is isolated by transformer, the waveform is shaped by the resonant circuit; finally, the shaped signal is demodulated by the data module of FSK-KQ330, after the data is demodulated, it is sent back to the microcontroller through the serial ports [12]. In the receiving-data part, it has a zero-crossing detection circuit. The function of the circuit is to detect the frequency of the sine wave signal on the power line. When the level of the signal passes through the zero point, the microcontroller sends or receives data.

The signal flow diagram of the carrier module is shown below.

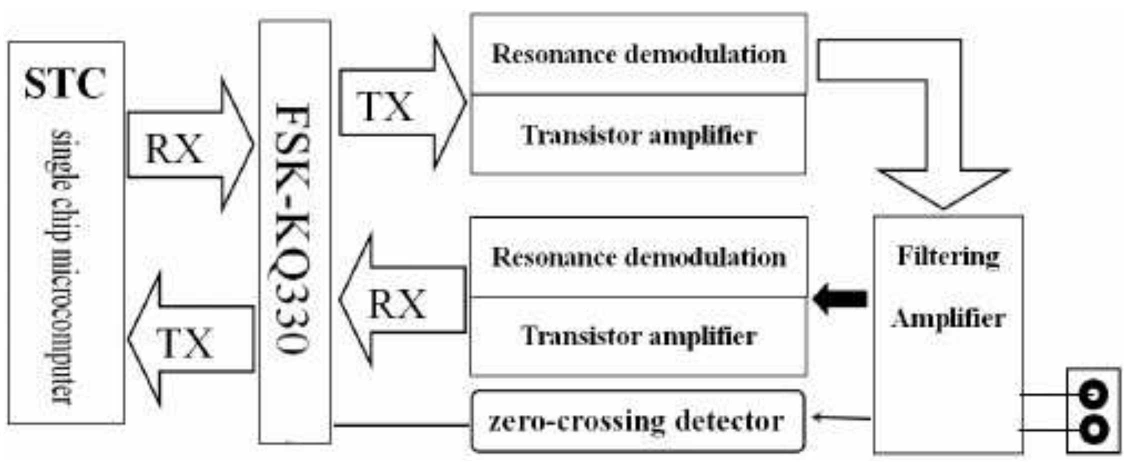

Figure 2. The signal flow diagram of the carrier module

3. The design of system hardware circuit

3.1. The data transmitting circuit

The circuit is mainly includes the magnifying circuit of triodes, the resonant circuit and the transformer isolation circuit. The resonant circuit enables waveform signal more stable and no noise [13].

3.1.1. The transmitting circuit principle diagram

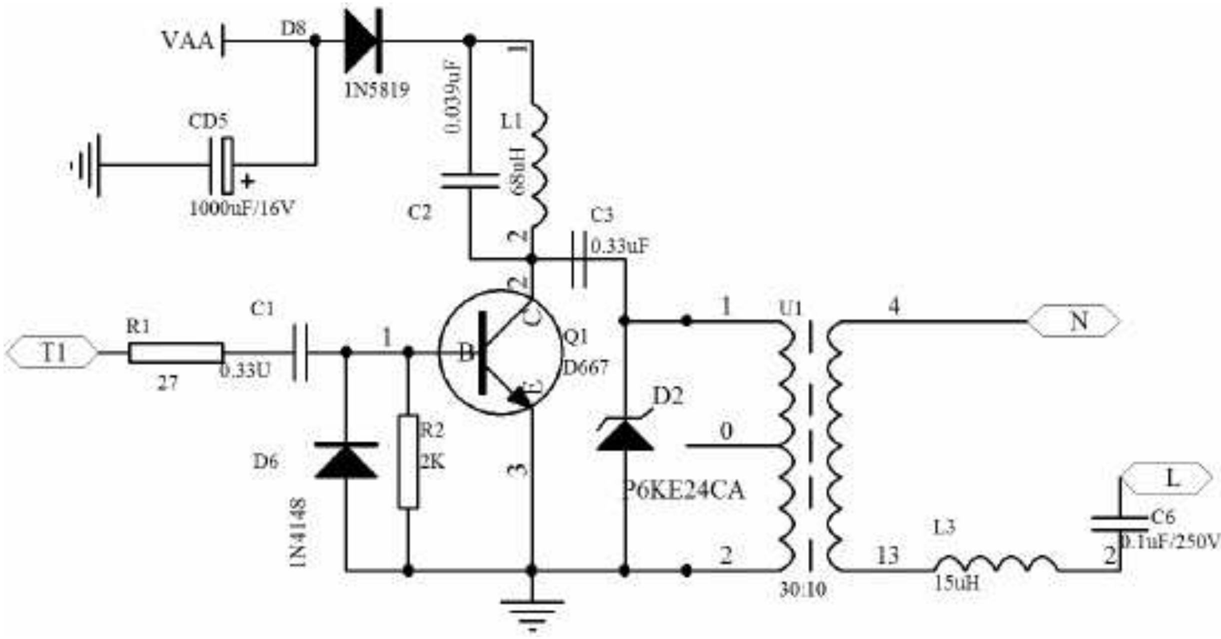

Figure 3. Transmission circuit

3.1.2. Circuit analysis

In the power line carrier communication system, the operation of the data transmitting circuit is described as follows: the FSK-KQ330 module's 8 pin outputs the square wave signal, and then it is coupled to the power line, after it is magnified and detected. The role of R1 and C1 is limiting the current. The transistor Q1 amplifies the signal. L1 and C2 constitute a resonant circuit. This role of the circuit is able to change the output square signal form FSK-KQ330 module's 8-pin into sine wave. Then it amplifies the signal from the transistor Q1;the function of the transformer is to isolate the interference and let the current to become lager [14].

3.2. The data receiving circuit

This circuit is mainly includes the magnifying circuit of triodes, the resonance detection circuit [15], the transformer isolation circuit, and the zero-crossing detection circuit.

Receving circuit is connected to power lines, and it sents the data signal to the module. The main function of the receiving circuit is detection. When the waveform signal is detected and is amplified, FSK-KQ330 module can identify the normal state [16].

3.2.1 The circuit principle diagram

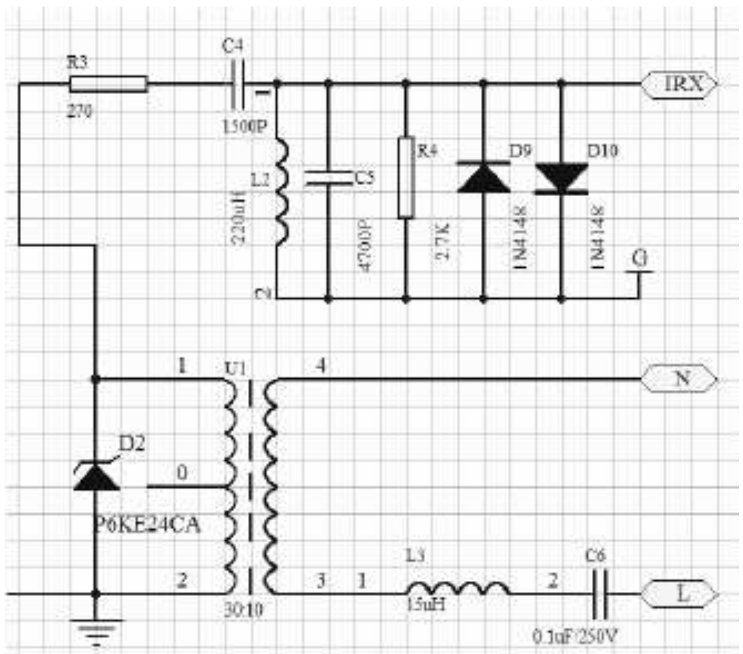

Figure 4. The receiving circuit diagram

3.2.2. Circuit analysis

The workflow of receiving circuit is described as follows: firstly, the signal in power line enters the receving pin (1 pin) of FSK-KQ330, after acrossing the peripheral circuits. The function of the peripheral receiving circuit is that the resonant circuit selects frequency. Namely, it uses FSK-KQ330 to identify the signal frequency. After the transformer isolating interrupt signal and the resonant circuit selecting signal frequency and amplifying signal, it uses two reverse diode which filter out the signal of too large magnitude to protect FSK-KQ330 module [17]. Secondly, L3 and C6 constitute the resonance circuit, it can let the wanted signal produce resonance. The role of the resonance circuit is amplifying signal and detecting signal. It is the same as the function of the radios' resonant circuit which can extract the waveform of the singal; L2 and C5 also constitute the resonance circuit. Its roles is further amplifying signal and detecting signal to filter out the unusful waveform signal [19]. The role of two reverse diode (1N4148) is that limit the waveform amplitude and let it is less than 0.7V voltage. Therefore, the circuit can identify the useful waveform and protect the FSK-KQ330 module effectively.

3.2.3. Zero-crossing detecting circuit

The role of zero-crossing detecting circuit is to detect sine wave in the power line. When the sine wave goes through the zero point, the data signals can be transmitted stably and the waveform amplitude does not change greatly. Zero-crossing detecting circuit is shown below.

3.3. FSK-KQ330 line carrier module

The module uses low voltage power line as the media of the signal (data) transmission. The carrier frequency of the signal (data) modulated by the module is 50 kHz~350 kHz. The high frequency signal in the low voltage power line can be transmitted to the distance.

The pin diagram of the module is shown in figure 5.

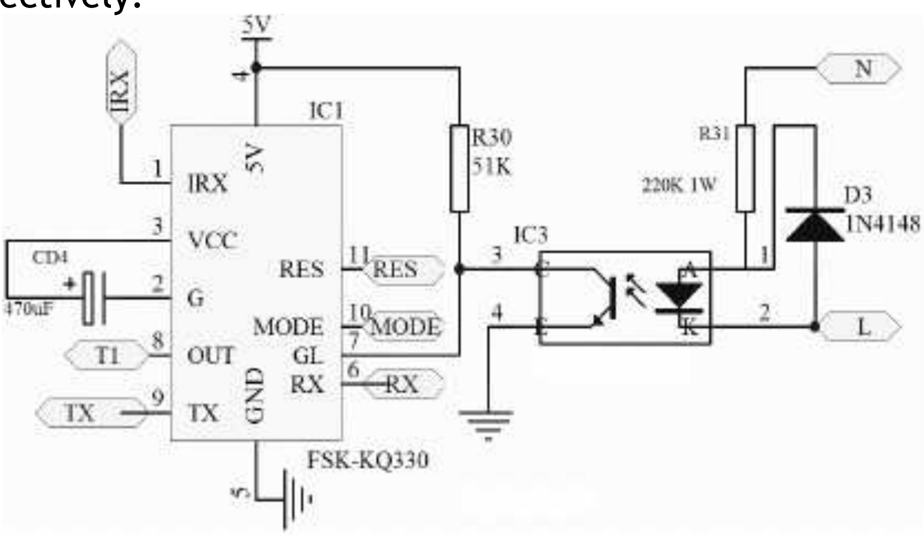

Figure 5. Zero-crossing detecting circuit

The 1pin is the foot of the input data.The 8 pin is the foot of the output data. The operating voltage of the module is +5v.

4. System Software Design

4.1. Communication Protocol

The system communication protocol is mainly to ensure that the data which are transmitted will not be interfered with the data of other slave machines. It ensures the quality of the communication. In addition, the agreement reduces the cost of communication in some certain extent. It helps identify the source of the signal and realizes the exchange of the machines.

In this article, the communication protocols ensure the quality of data transmission. In the course of data reception, only the data packets which meet the communication format can trigger the corresponding function, which reduces the chance of error and data corruption.

The communication protocol of the system organizes data by packets and also sends data by packets. Data transmission format is a frame format. When the carrier module is the sending-data state, data is sent to the power line; when the data transmission is complete, the carrier module is set to the receiving-state. Data frame has a fixed format [21]. It includes the start code, the length code, the data content and the end code. The start code is the head of each data packet, which is indicated as "#"; the length code is the total length of the current packet; the end code is the end of each packet of data symbol, which is indicated as "$". Command packet format is shown in Table1.

Table 1. Communication protocol packet format

Start code	Length code	Data	End code
#	0x（length）	Content	$

The way of the carrier module is a self-defined way. If the data to be sent is # 0x06, 0x12, 0x34, 0x56, 0xFA, 0x91, 0x54$", so 0x06 is at the second place in the packet, which indicates that the data content length is six. The data behind 0x06 is the data content, which is 0x12, 0x34, 0x56, 0xFA, 0x91, 0x54".

Because there are many interference signals in the power line, the start code shall be strictly determined. The serial port baud rate is 9600 bps. When the start code of the received data is # and the end code of the received data is $, the data is valid data. Otherwise, the data will be abandoned and it re-searches the next start code.

According to the data's transfer direction, data communication can be divided into three kinds of work mode: the simplex mode, the half-duplex mode and the full-duplex mode. In this paper, data communication uses the half-duplex mode which cannot send or receive data at the same time [23].

4.2. Communication Process

4.2.1. The flowchart of send subroutine

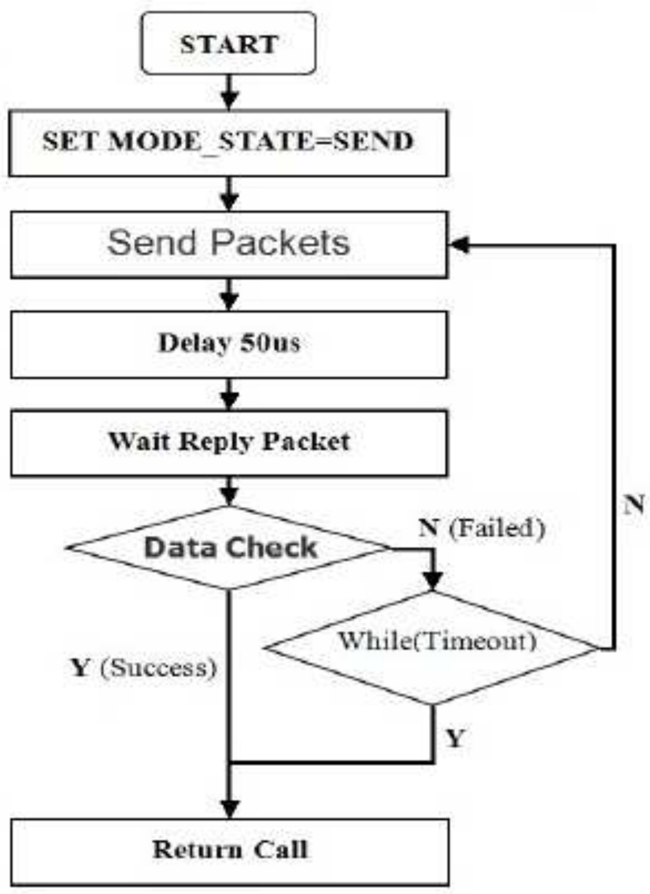

Figure 6. Zero-crossing detecting circuit

4.2.2. Packet reception interrupt program flowchart

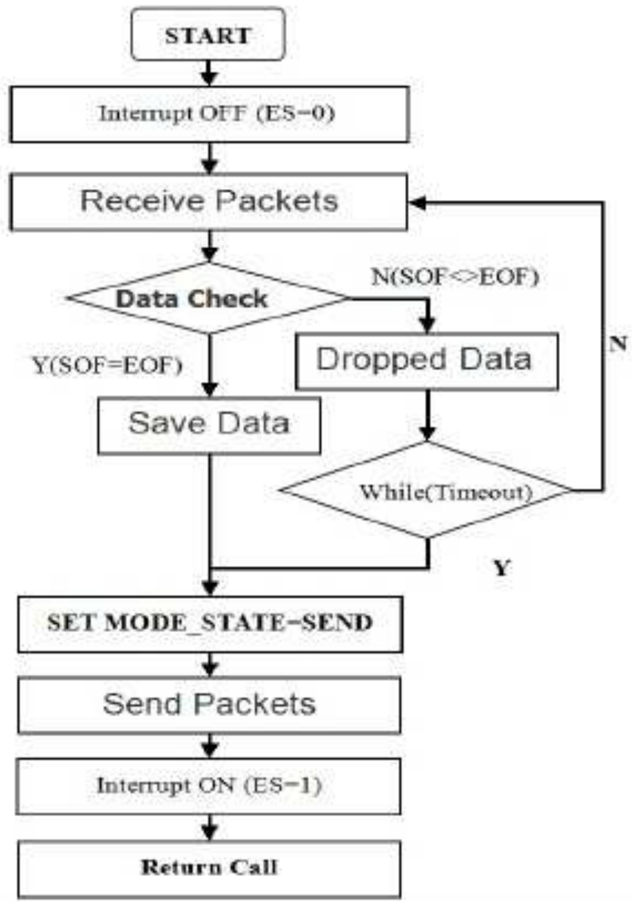

Figure 7. Packet reception interrupt program flowchart

5. Analysis of experimental results

By analyzing the experimental data achieved from the test, we found that the actual signal values are close to the theoretical values. The system can work stably.

5.1. The signal of FSK-KQ330 module transmit-pin

When there is no data to be transmitted, the signal in the transmit-pin is a straight line. When data is transmitted, the signal in the transmit-pin is a square wave signal. It is as shown in Figure 8. Test point is in the base pole of the transistor.

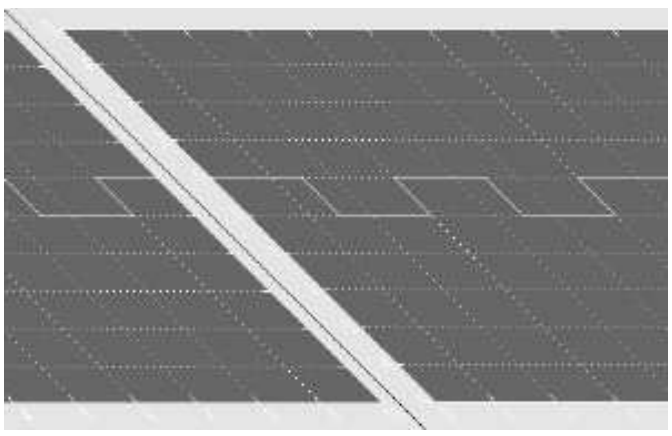

Figure 8. Theoretical value of carrier module output signal

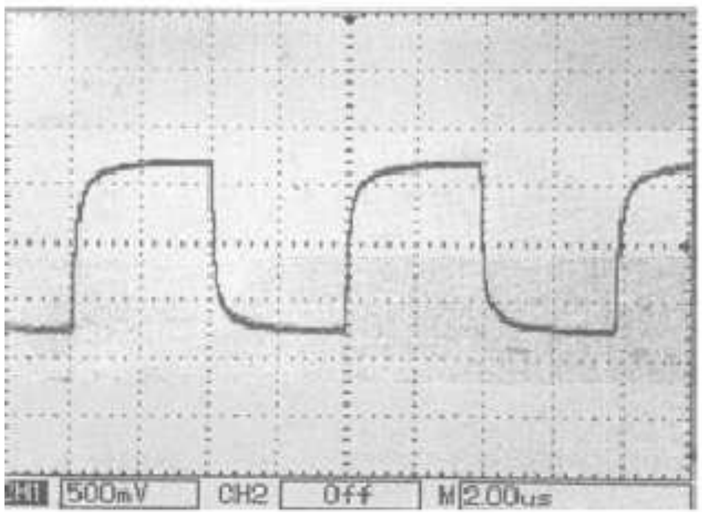

Figure 9. The actual value of the carrier module output signal

5.2. The waveform received by carrier module

The signal received by the carrier module is a sine wave signal, which is filtered out from the 220V AC [24]. It goes through the resonant circuit module.

After resonance filtering and waveform processing, the signal is the stable sine wave. The actual signal values by testing are close to the theoretical values.

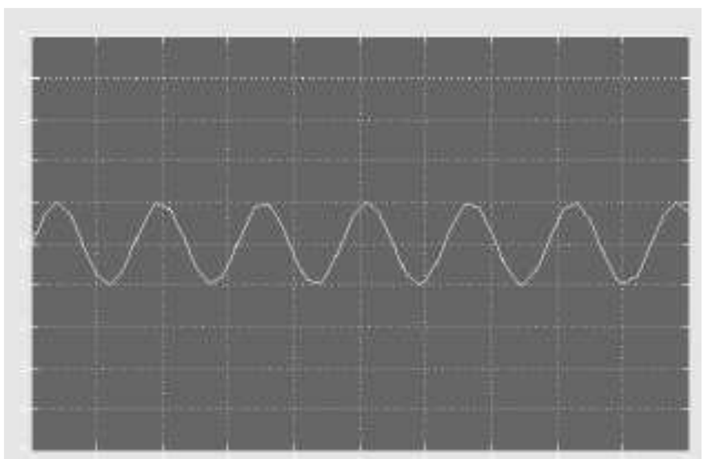

Figure 10. Theory carrier signal value at the receiver module

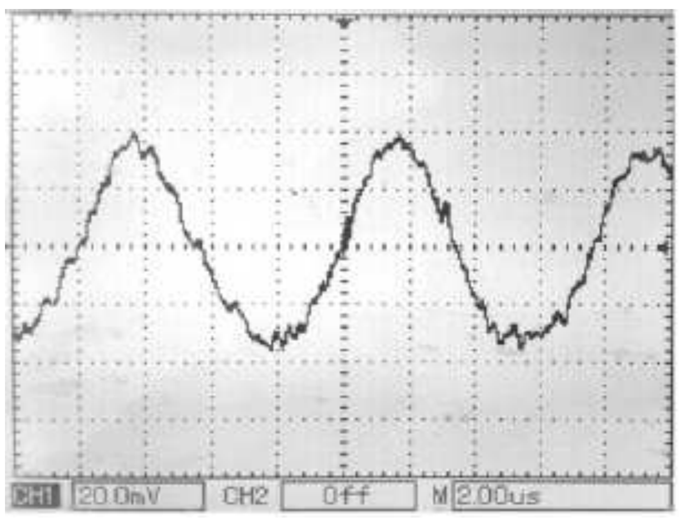

Figure 11. The actual signal value at the receiver module

6. Conclusions

The low-voltage power line carrier communication system is designed to transfer 50 Hz power. At the same time, more and more modern family use electric equipment (such as microwave ovens, induction cooker, electric power, washing machine, computer, vacuum cleaners and other equipment). The electric equipment is mostly the inductance type equipment.

Because the electric equipment exists the difference of quality and performance, electric equipment itself can bring interference to the power lines and generate a lot of noise in power lines, which restricts the quality of signal transmission. This design uses the multilevel filter amplifier circuit, which can effectively filter out noise and make the received signal by the slave machines clean and smooth. It is shown in figure 8,9,10 that after the full control signal (square wave signal) is modulated by the master machine, through the power line transmission to the slave machine, the sine wave signal can be demodulated by the slave machine,which is close to clean and smooth. The design of low-voltage power Line carrier communication system based on FSK-KQ330 module has the characteristics of the simple hardware circuit and low cost. The design can provide reliable guarantee for data communication based on single chip microcomputer . The scheme can apply to intelligent home system ,and It can also be used for the remote control of the intelligent switch and the intelligent equipment.

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8. Biography

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