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Design of frequency modulation transmitter in communication system

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Abstract

This paper designs the FM transmitter system. The transmitter selects the audio with amplitude of 200mV and frequency of 2KHz as the input signal, and then designs an audio signal transmission system with resonance frequency of about 46mhz and power amplification factor of 40-50 according to the design index. I mainly design, simulate and test the frequency modulation module. After consulting the relevant literature and comparing the frequency modulation circuits, I finally choose the voltage controlled oscillator for frequency modulation and the class A and class B amplifier circuit for power amplification. Then the circuit is simulated and tested with MATLAB. It is found that the simulation and test results are roughly consistent with the expected indicators, and finally the frequency modulation, amplification and transmission of audio signal are completed.

Keywords

Voltage controlled oscillator class A and class B power amplifier circuit MATLAB.

1. Overall design of FM transmitting circuit

1.1. FM transmitter system block diagram

At the beginning of this design, it is planned to use PLL, mixer, frequency multiplier and high-frequency power amplifier in the frequency modulation module. However, considering the complexity of the system and the compatibility of the parameters of each module in the actual test, the overall design is adjusted. The audio signal is input to the voltage controlled oscillator to realize frequency modulation, and then the signal is transmitted to the high-frequency power amplifier, and then transmitted to the transmitter through the antenna switch. The carrier frequency is about 45-46mhz. The system block diagram of FM transmitter is shown in Figure 1.1.

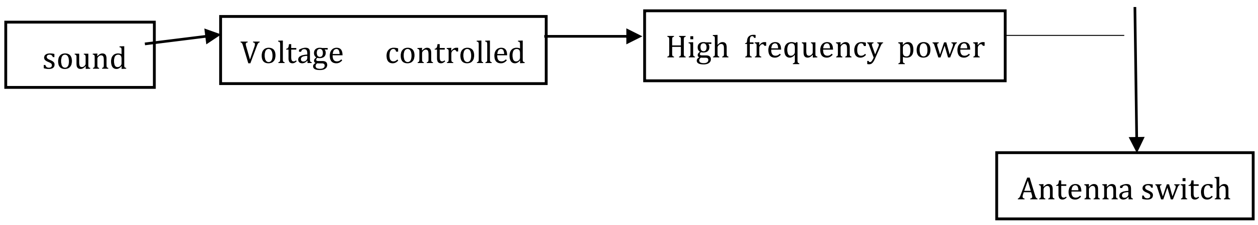

Figure 1.1 FM transmitter system block diagram

1.2. FM receiver system block diagram

In order to complete the design of the whole system, the system block diagram of FM receiver is shown in Figure 1.2

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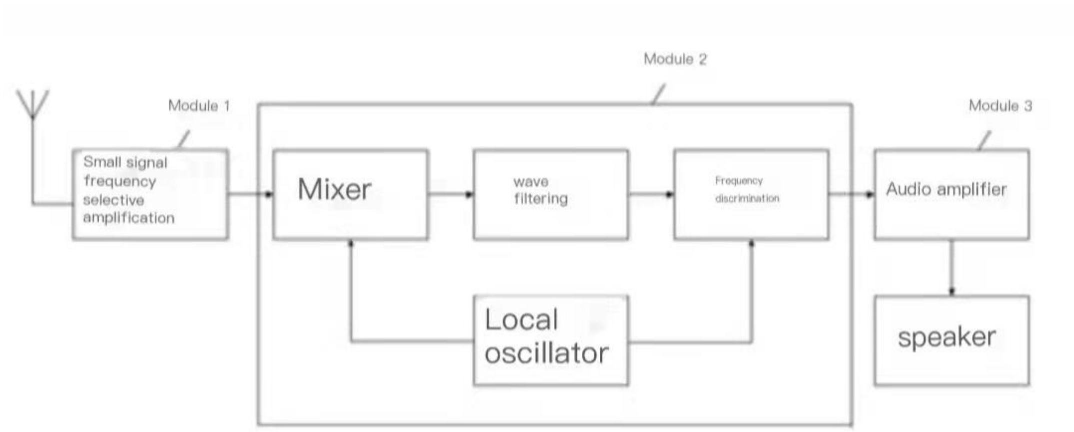

Figure 1.2 system block diagram of FM receiver

2. Circuit design of FM module

2.1. Comparison and selection of FM module schemes

(1) Varactor direct frequency modulation circuit: varactor is a diode designed according to the principle that the junction capacitance of PN junction changes with the change of reverse voltage. Its inter electrode structure and volt ampere characteristics are not much different from those of general detection diodes. The difference is that when the reverse bias is applied, the varactor II presents a large junction capacitance. The capacitance of this junction can change sensitively with the reverse bias voltage. Using the - characteristic of the varactor diode, the varactor diode is connected to the oscillation circuit of the oscillator as a controllable capacitor element, and the capacitance of the circuit will change with the modulation signal voltage, so as to change the oscillation frequency and achieve the purpose of frequency modulation [1].

(2) Frequency modulation circuit of voltage controlled oscillator: voltage controlled oscillator (VCO) is an important part of RF circuit. Most RF circuits use modulation and demodulation, so they rely heavily on local oscillator. Modern communication technology requires new technologies such as multiplexing and frequency hopping. One of the means to realize these technologies is to use voltage to control the capacitance of the capacitor in the oscillation circuit, and then change the resonance frequency of the oscillation circuit [2].

The center frequency stability of varactor direct frequency modulation circuit is poor[3].In order to obtain high stability FM signal, frequency stabilization measures must be taken. The method used here is to directly tune the crystal oscillator. Compared with ordinary local oscillator, VCO has more electronic control devices in the resonant circuit, such as varactor diode; Generally, VCOs mostly exist in the form of clapper oscillator to ensure the stability of circuit operating point and Q value. Therefore, this design adopts voltage controlled oscillator frequency modulation circuit.

2.2. Design of voltage controlled oscillator circuit and various indexes

2.2.1 Design of voltage controlled oscillator circuit

The electrical schematic diagram of the VCO is shown in Figure 2.1. It is the characteristics of the varactor that are used to realize the VCO experiment.. It should be noted that the 1 terminal of W401 is grounded and the 3 terminals are connected with + 5V power supply. The oscillator is composed of varactor diodes D402, C410, C405,C406, T401 and Q401. Its working principle is as follows: the 1 and 2 pins of K402 are connected → W401 rotates clockwise (the 2 ends are close upward) → the voltage drop at both ends of D402 increases → the capacitance of D402 decreases → the oscillator frequency increases → the purpose of voltage controlled oscillation is achieved.

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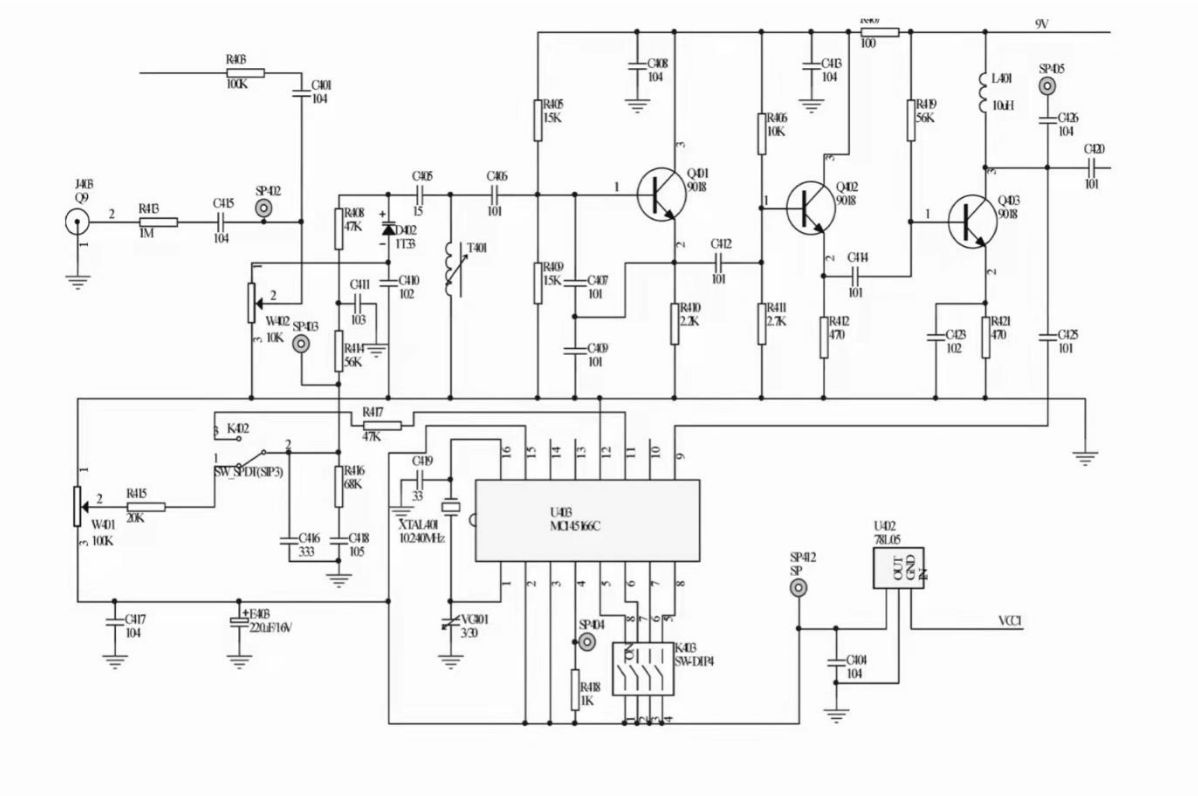
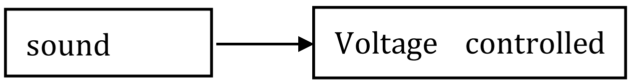


Figure 2.1 circuit schematic diagram of voltage controlled oscillator

2.2.2 Design and calculation of indicators

Before the simulation and actual test, the index setting of each module is particularly critical. Next, the indexes of audio signal input module and voltage controlled oscillator module are designed.



Input amplitude of audio signal $U_{\Omega} = 200mV$, $f_{\Omega} = 2KHz$; VCO carrier frequency $f_c = 46KHz$,maximum frequency offset$\Delta f_m = 100KHz$. Bandwidth calculation is shown in formula (2-1) and formula (2-2):

$$m_f = \frac{\Delta f_m}{f_{\Omega}} = \frac{100KHz}{2KHz} = 50 \quad (2\text{-}1)$$

$$BW = 2(m_f + 1)f_{\Omega} = 2 \times (50 + 1) \times 2KHz = 204KHz \quad (2\text{-}2)$$

2.3. Simulation result

The frequency modulation module of VCO is made by using Simulink in MATLAB, as shown in Figure 2.2.

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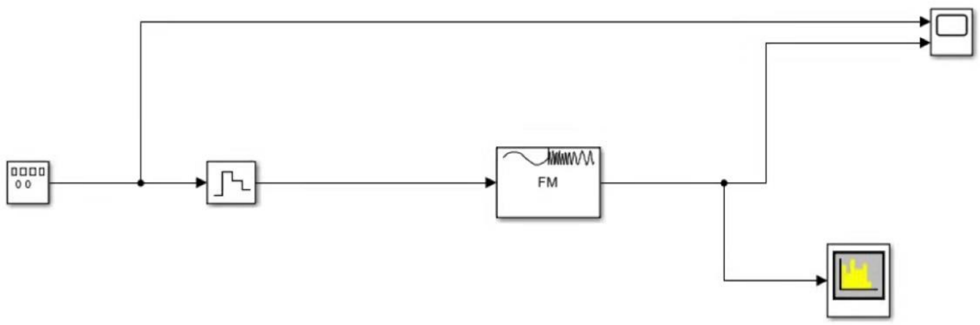

Figure 2.2 simulation diagram of FM module in MATLAB

After using the indicators designed in 2.2.2 to set the initial values for each module, the waveforms of audio signal and modulated signal are measured on the oscilloscope and found to be consistent with the principle and indicators, as shown in Figure 2-3.

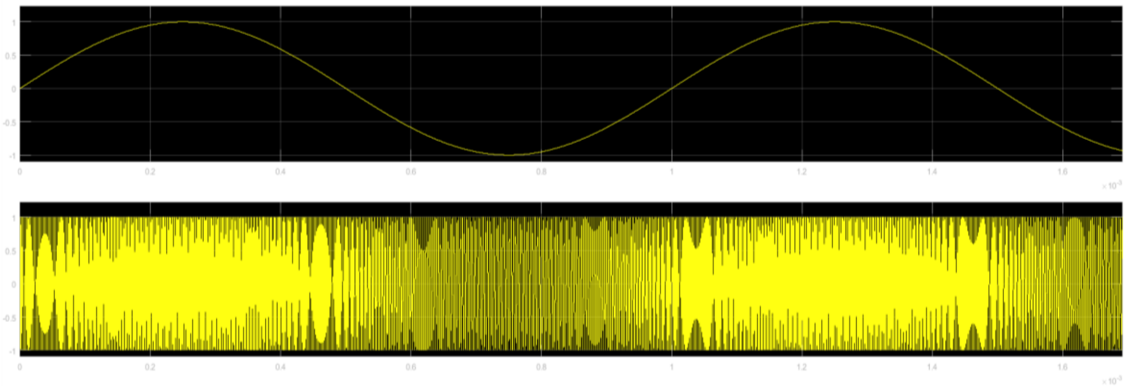

Fig. 2-3 simulation waveform of audio signal and modulated signal

2.4. Test result

Adjust w401 so that the potential V1 at sp403 changes between 0 and 4.5V, and record the frequency f0 measured at sp405. After sorting out the data, fill in Table 2.1:

Table 2.1 voltage frequency relationship

V_1/V	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
f_Ω $/MHz$	45.80	45.91	46.02	46.19	46.50	46.59	46.81	47.03	47.21	47.45

Then the frequency versus voltage curve is drawn by MATLAB. As shown in Figure 2.4.

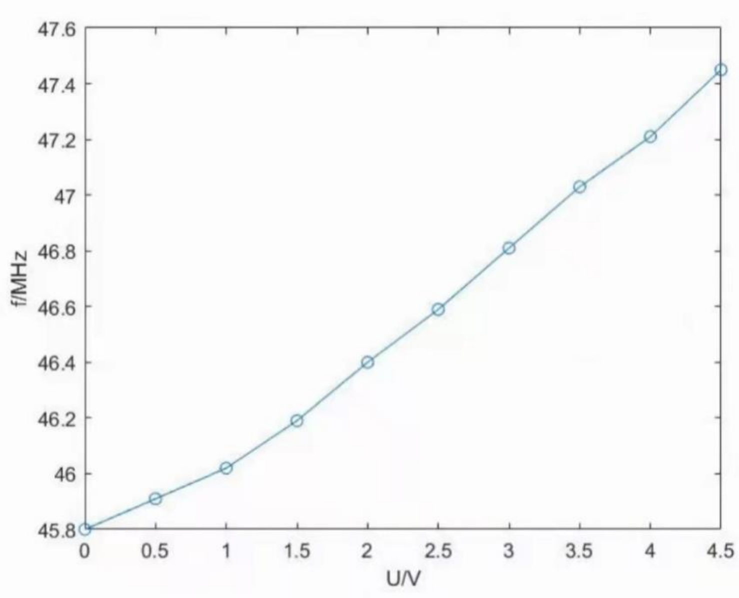

Fig. 2.4 variation curve of frequency with voltage

Therefore, the oscillation frequency is:46.5 MHz. The calculation of pressure control sensitivity is shown in formula (2-3):

$$s = \frac{\Delta f}{\Delta U} = 364KHz/V \tag{2-3}$$

3. High frequency power amplifier module

3.1. Comparison and selection of high frequency power amplifier module schemes

The working state of the power amplifier is determined according to the conduction angle of the amplifier current θ The scope of can be divided into class A, class B, class C and class D. Current conduction angle of power amplifier θ The smaller the, the higher the efficiency of the amplifier η Higher [4].

Design of class a power amplifier θ= ± 180o, efficiency η It can only reach 25% at most. It is suitable for small signal and low power amplification. It is generally used as an intermediate stage or a final stage power amplifier with small output power.

The current conduction angle of nonlinear class A and class B power amplifier is 90 °≤ θ ≤ 180 °, the efficiency can reach 50%. It is usually used as the last stage power amplifier of the transmitter to obtain larger output power and higher efficiency. Conduction angle of class C nonlinear power amplifier θ ≤ 90°, the efficiency can reach 80%. It is usually used as the last stage power amplifier of the transmitter to obtain larger output power and higher efficiency.

In order to realize effective wireless long-distance communication, there must be strong transmission signal. In order to obtain a signal with sufficient strength (power), a power amplification circuit is needed to solve the problem. This design uses a Class A and B power amplification circuit to improve the output power of the signal [5].

3.2. Design of high frequency power amplifier circuit and various indexes

3.2.1 Design of high frequency power amplifier circuit

In this system, according to the practical application, class A and class B power amplifiers are used to amplify the power of high-frequency signals. The experimental electrical schematic diagram of high frequency power amplifier is shown in Figure 3.1. The signal is coupled into

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q404 through c424 for amplification, and then transmitted to the space through the antenna through the LC resonant circuit composed of t402 and c422.

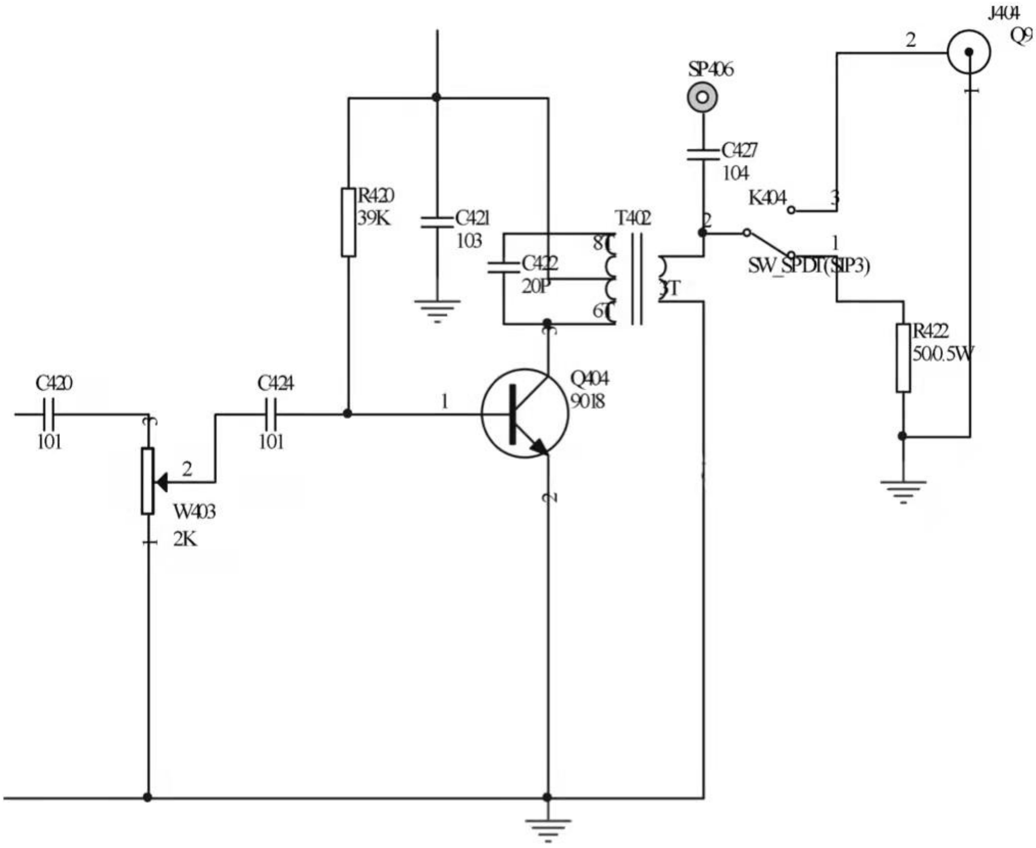

Figure 3.1 circuit schematic diagram of class A and class B power amplifier

3.2.2 Design and calculation of indicators

Input impedance of high frequency power amplifier:$R_i = 39K\Omega$, output impedance:$R_o = 50\Omega$; input voltage$U_i = 8V$, output voltage:$U_O = 2.5V$; Input powerP_i. output power$P_o$and power gainA_p the calculation of is shown in formula (3-1), (3-2), (3-3).

$$P_i = \frac{U_i^2}{R_i} = \frac{8V \times 8V}{24K\Omega} = 2.6mW \quad (3\text{-}1)$$

$$P_o = \frac{U_O^2}{R_p} = \frac{2.5V \times 2.5V}{50\Omega} = 125mW \quad (3\text{-}2)$$

$$A_p = \frac{P_O}{P_i} = \frac{125mW}{2.6mW} = 48.1 \quad (3\text{-}3)$$

3.3. Simulation result

The frequency modulation module of VCO is made by using Simulink in MATLAB, as shown in Figure 3.2.

Use the indicators designed in 3.2.2 to set the initial value for each module and measure it$P_i = 2.68mW, P_o = 130mW, A_p = 48.5$， It can be seen that the simulation results are roughly consistent with the design indicators.

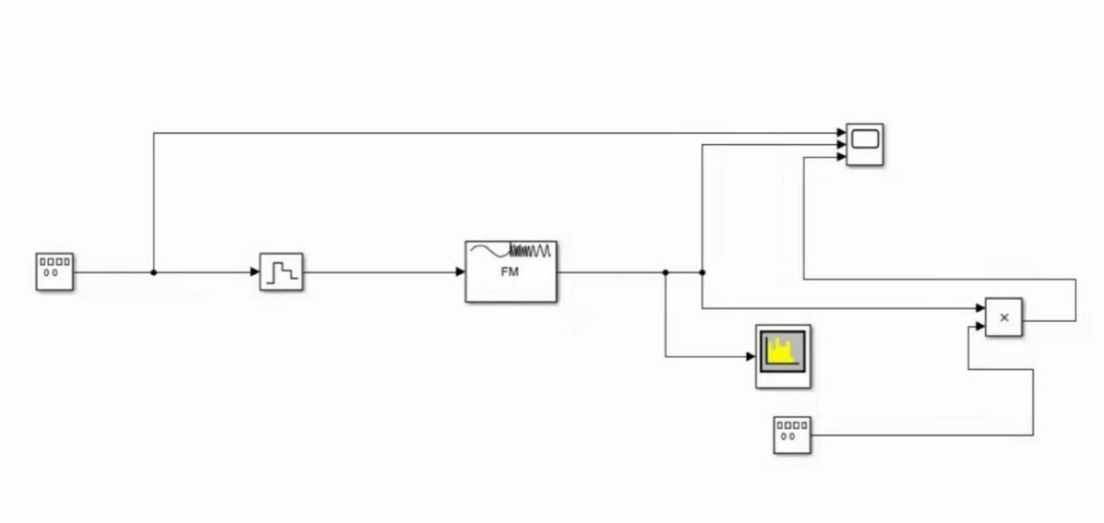

Figure 3.2 simulation diagram of power amplification module in MATLAB

3.4. Test result

As shown in Figure 3.1: use an oscilloscope to observe the waveform at sp406 (oscillator output sine wave), and properly adjust t402 to make the amplitude at sp406 reach a maximum value. Connect 1 and 2 of k404, adjust w403, measure the output voltage waveform with oscilloscope, measure the output voltage with high-frequency millivoltmeter, and record the calculated data in Table 3.1.

Table 3.1 test results of high frequency power amplifier module

input voltage /V	7.41	7.6	7.83	7.92	8.05	8.21	8.3
output voltage /V	1.80	1.95	2.05	2.26	2.45	2.61	2.78
input power /mW	2.29	2.41	2.55	2.61	2.70	2.81	2.87
output power /mW	64.80	76.05	84.05	102.152	120.05	136.242	154.568
power gain	28.32	31.60	32.90	39.08	44.46	48.51	53.84

By continuously adjusting w403, the gain fluctuates between 28 and 55, which is in line with the expected index, and the test result is good.

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