Audio Amplification Circuit Design

1.Purpose

1. Master principle and design method of small signal amplifier circuit
2. Understand the principle of integrated amplifier
3. Master design procedure and debugging method of electrical circuit

2. Contents

Design a audio amplifier circuit, the input of microphone is smaller than 10mV, the technical indices of the circuit:

1. Input impedance>100KΩ
   CMRR (Common Mode Rejection Ratio)>60dB
2. Passband: 300Hz~3KHz
3. Maximum undistorted output power ≥1W
   Load impedance RL=16Ω
   Source voltage: 10V
4. The input of preamplifier<10mV

3 Requirements

Design circuit, give more than two schemes, use multisim to simulate the circuit, select proper parameters and elements, then connect elements, debug and test.

4 Principle

4.1 Preamplifier

The output of microphone is usually about 5mV, but the common mode noise(CMN) can reach to several volt, so the input drift, the noise and CMMR are significant factors. The preamplifier should be a high input impedance, high CMMR, low temperature drift small signal amplification circuit which can be matched to high impedance microphone.

4.2 Bandpass filter

The frequency range which can be heard by human ears is 20Hz~20KHz, and the human voice frequency range is 80Hz~3.4KHz, but the audio signal frequency range is about 300Hz~3KHz, that's why a bandpass filter is necessary after preamplifier.

4.3 Power amplification circuit

The output of circuit will be used to make speaker sound and transfer electrical signal to sound signal, and a power amplification circuit is needed for output terminal to enhance output power and transfer effect. And distortion should be suppressed. In this circuit a LM1875 is used as power amplifier.

4.4 Combine modules

The audio amplification circuit is composed of several parts:

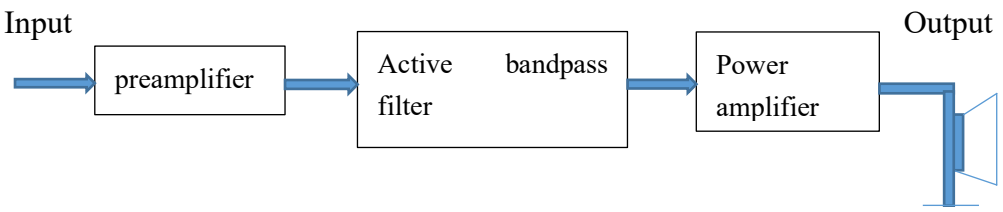


Fig.1 Diagram of voice amplifier

According to design requirement a voltage magnification should be confirmed. Considering that there are several stages of amplifier, the

magnification will be devided and assigned to each stage. Then proper element parameters should be set. At last a circuit will be installed on breadboard.

5 Chips

5.1LM324N

5.11 LM324N pins

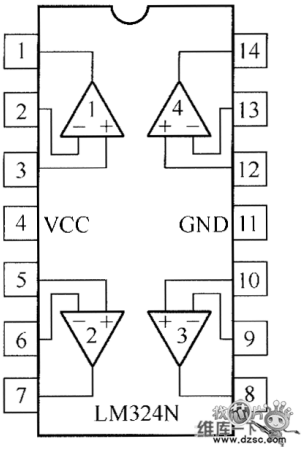


Fig.2 LM324N pins

5.12 LM324N function

LM324N is a four op amp integrated circuit which consumes low power and works in wide voltage range. It takes 14 pin DIP and it contains phase compensation circuit.

5.13 LM324N parameters

Voltage gain	100dB
Voltage gain width	1MHz
Source range	3V~30VDC
Input offset current	50nA~150nA
CMMR	70dB~90dB

Output current 40mA

5.2LM1875T

5.2.1 LM1875T pin

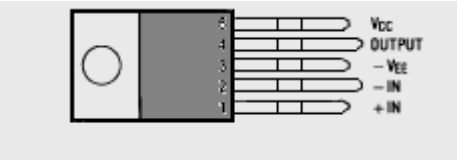


Fig.3 LM1875T pin

5.2.2 LM1875T function

LM1875 takes V type 5 pin SIP structure. When input source voltage range is ±25V and RL=4Ω the output power is 20W. When input source voltage is ±30V and the load is 8Ω its output power is 30W. Small size, high output power and small distortion are advantages.

5.2.3 LM1875T parameters

(1)LM1875 parameters

voltage range： 16～60V

static current： 50mA

output power: 25W

rated gain: 26dB

working voltage: ±25V

(2)LM1875 limit parameters

Source voltage(Vs) 60V

Input voltage(Vin) -VEE-VCC V

6 Circuit design

6.1Principle analysis

The audio signal enters the preamplifier and will be amplified. Then the signal is sent to second order active bandpass filter to filter out frequency which is not in the range 300Hz~3000Hz. Then the amplified and filtered signal will be sent to power amplifier and drive the speaker sound.

6.2 Preamplifier

6.21 Principle and parameters

The preamplifier circuit should be a high input impedance, high CMRR, low temperature drift circuit.

Two LM324N are applied to form non-inverting and inverting cascade.

6.22 Analysis

First stage amplifier：$Ui/R2=(Uo_1-Ui)/R3$

Second stage amplifier: $Uo_1/R6=(0-Uo)/R5$

And there will be $Uo=(1+R3/R2)*(-R5/R6)Ui$

The gain： $AUi=(1+R3/R2)*(-R5/R6)$

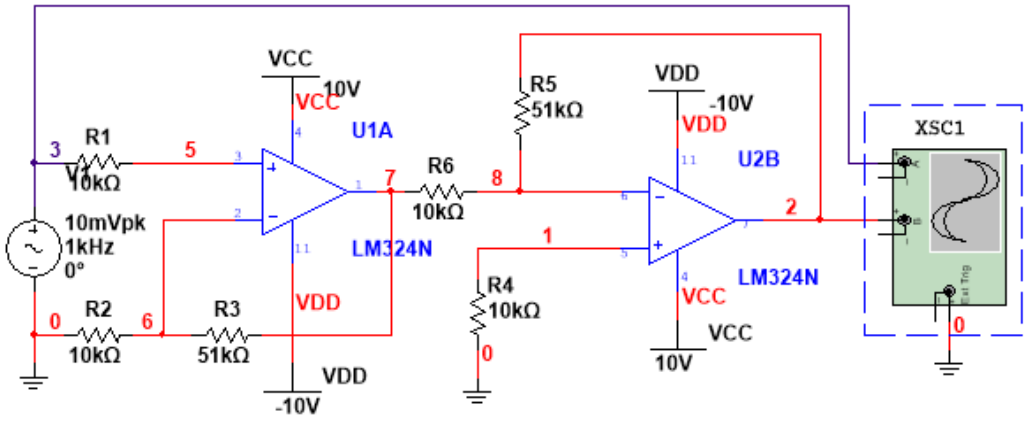


Fig.4 Preamplifier circuit

6.3Active bandpass filter

6.31 Principle and parameters

The frequency range which can be heard by human ears is 20Hz~20KHz, and the human voice frequency range is 80Hz~3.4KHz, but the audio signal frequency range is about 300Hz~3KHz, that's why a bandpass filter is necessary after preamplifier.

LM324N is used to form filter.

6.32 Analysis

(1)HPF

$f_{p1}=1/(2\pi * C\sqrt{R2R3})$ =318Hz~=300Hz

C=C1=C2=100nf,R2=R3=5K

(2)LPF

$f_{p2}=1/(2\pi * R\sqrt{C3C4})$=3183Hz~=3000Hz

C3=C4=10nf，R=R4=R6=5K

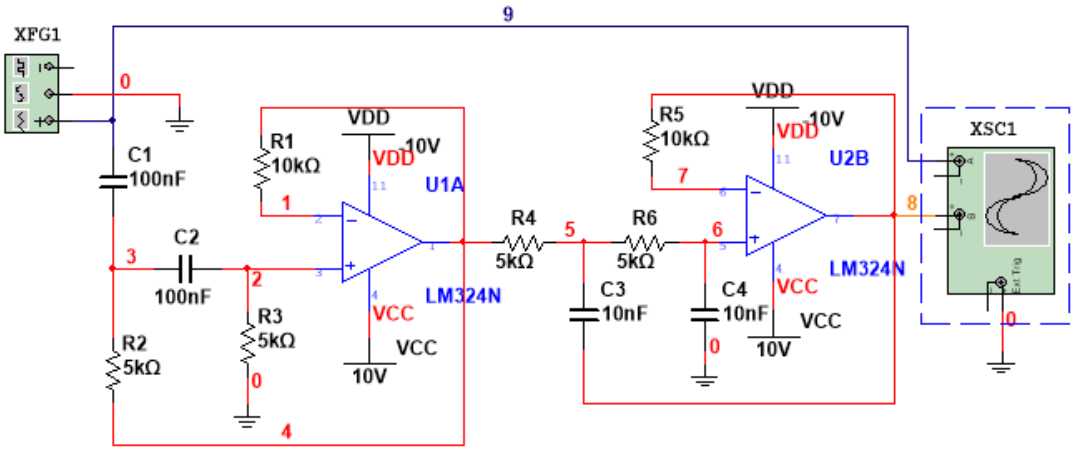


Fig.5 Active bandpass filter circuit

6.4 Power amplifier circuit

6.4.1 Principle and parameters

This part offers power to load, so the output power should be as high as

possible, with high transfer effect and low distortion.

A LM1875 is applied in this circuit.

6.4.2 Analysis

Gain: $AV_3 = R_5 / R_3$

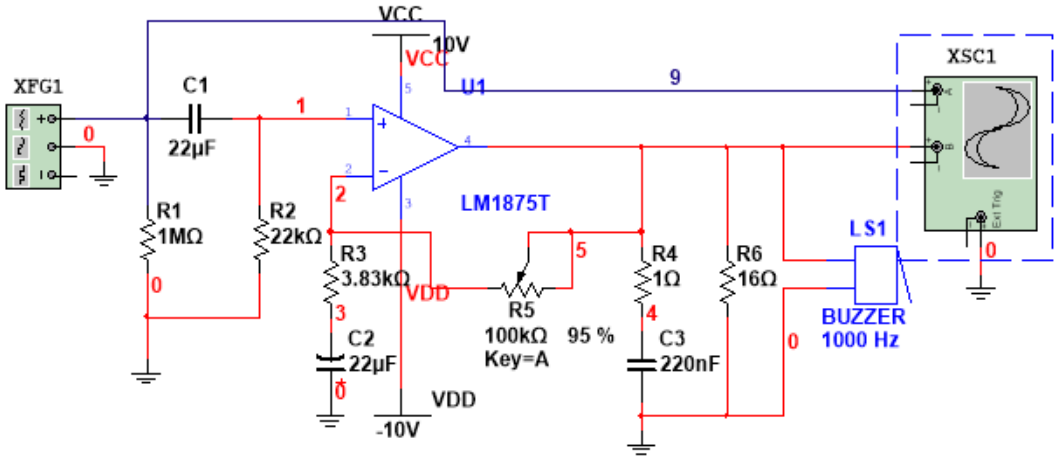
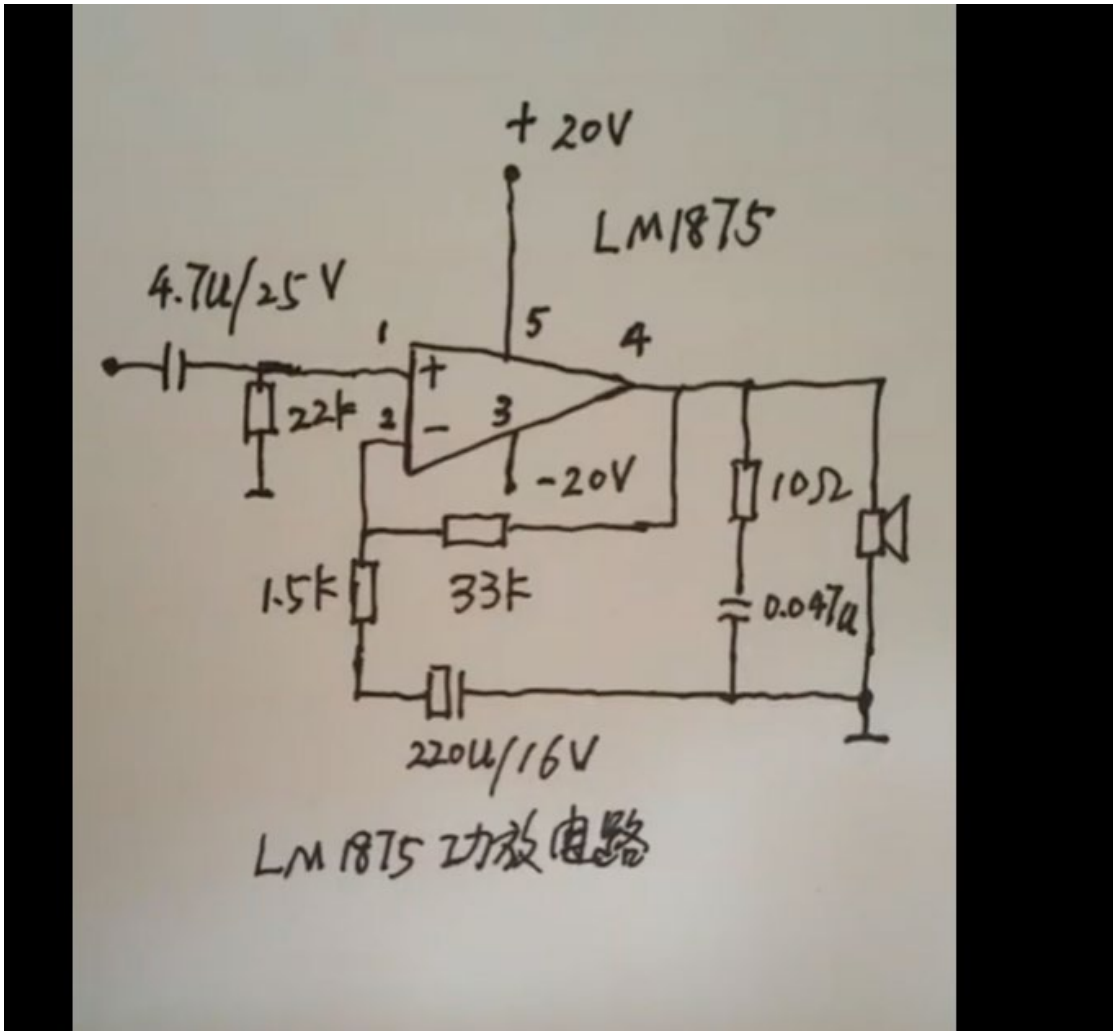
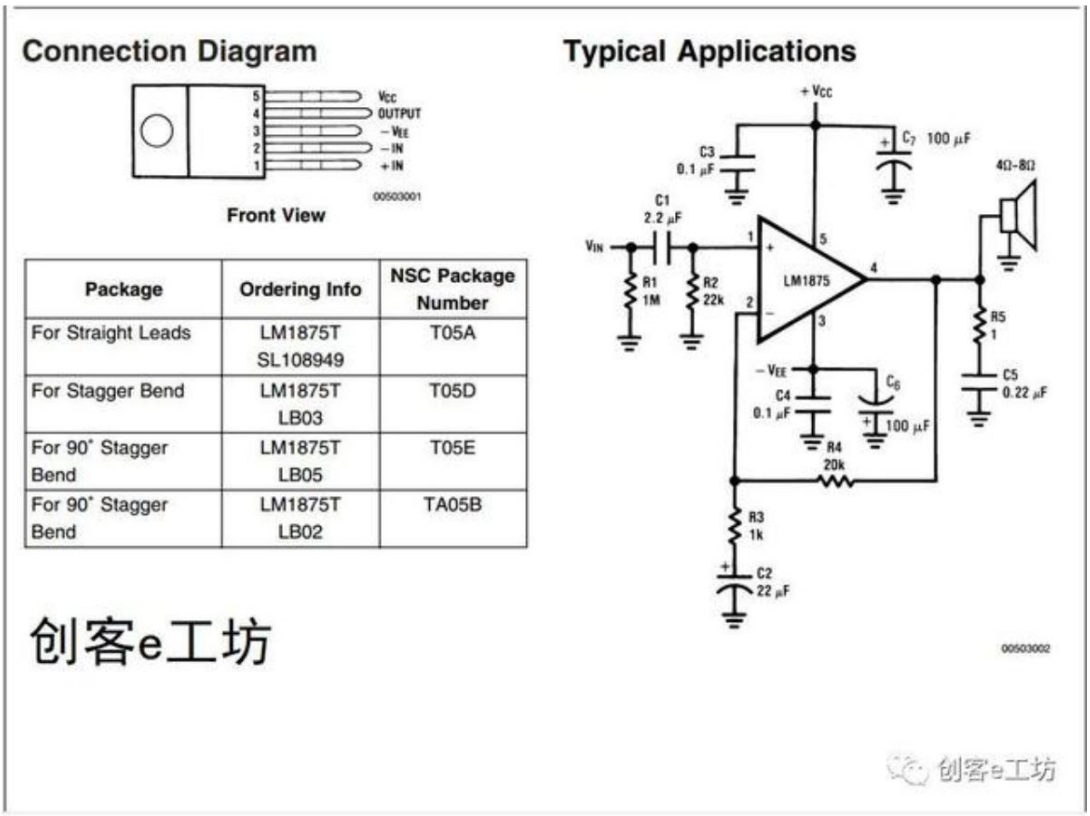


Fig.6 Power amplifier circuit

OR


+20V
LM1875
4.7u/25V
1
5
4
+
2
-
3
22k
-20V
10Ω
1.5k
33k
0.047u
220u/16V
LM1875 功放电路

OR



6.5 Overall

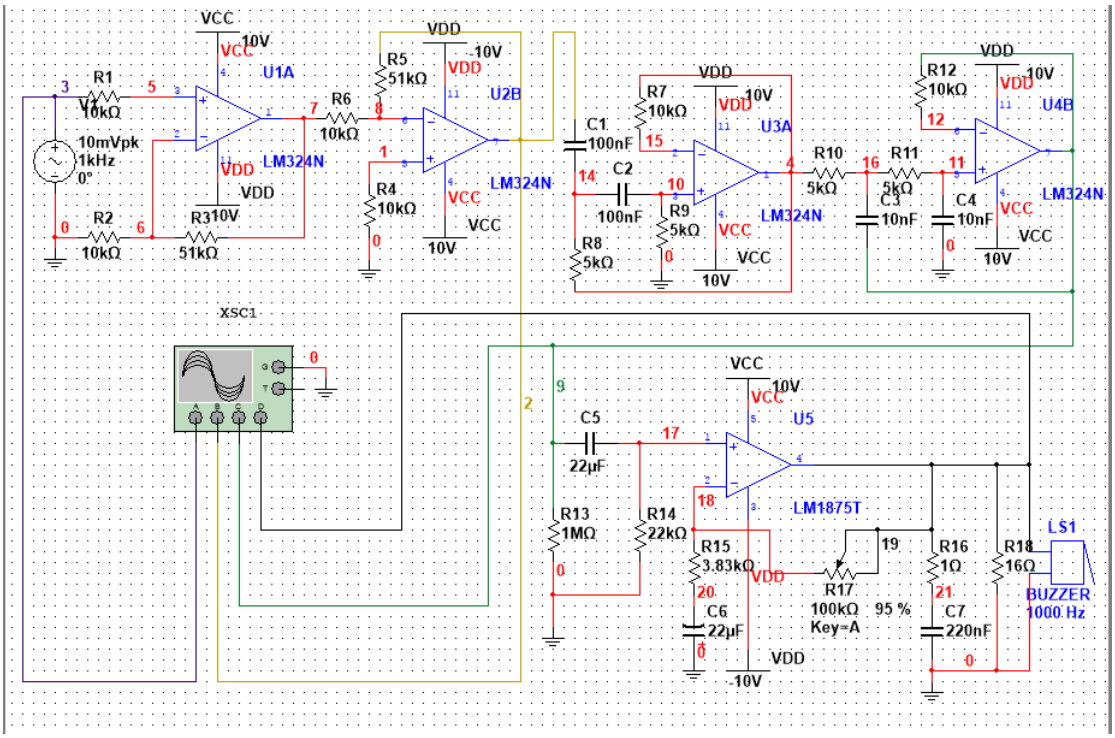


Fig.7 Overall circuit

7 Multisim simulation

7.1 Preamplifier

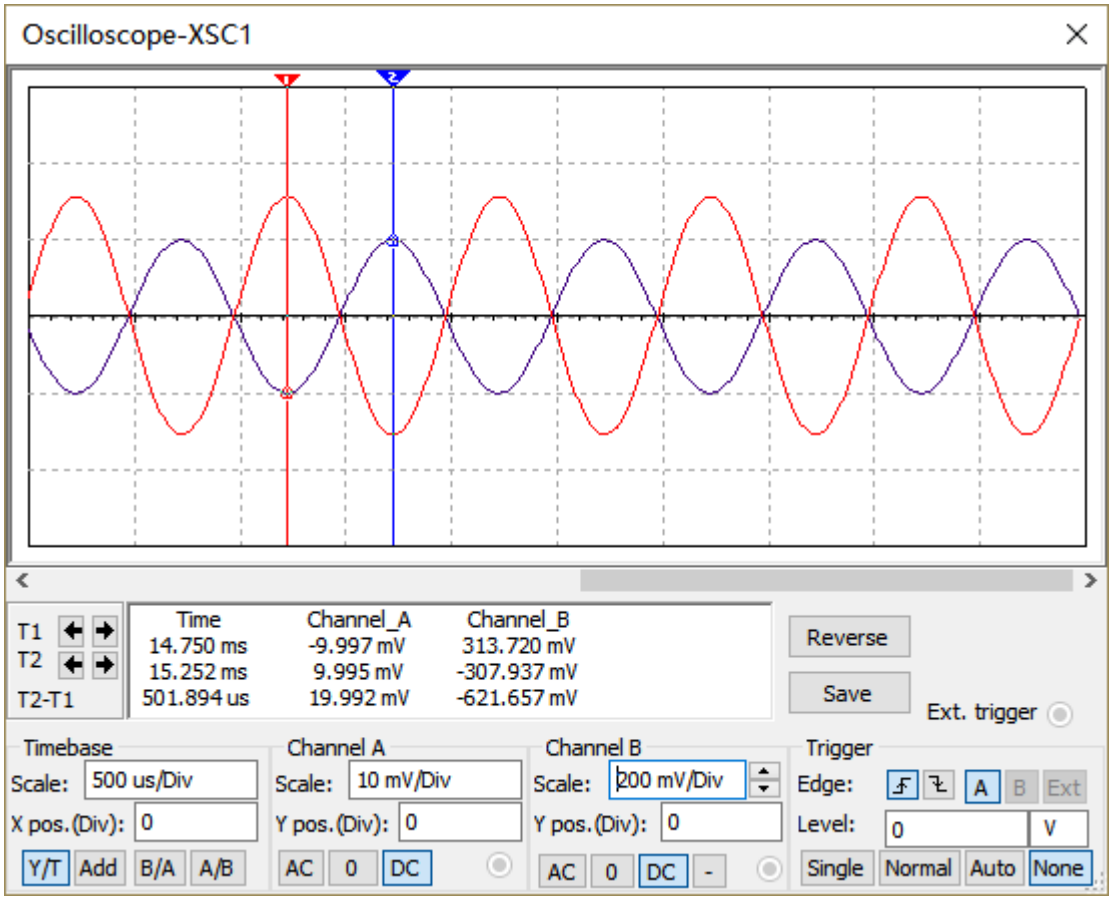


Fig.8 Preamplifier simulation results

Input peak：9.995mv

Output peak：307.937 mv

Gain：30.8

7.2 Bandpass filter

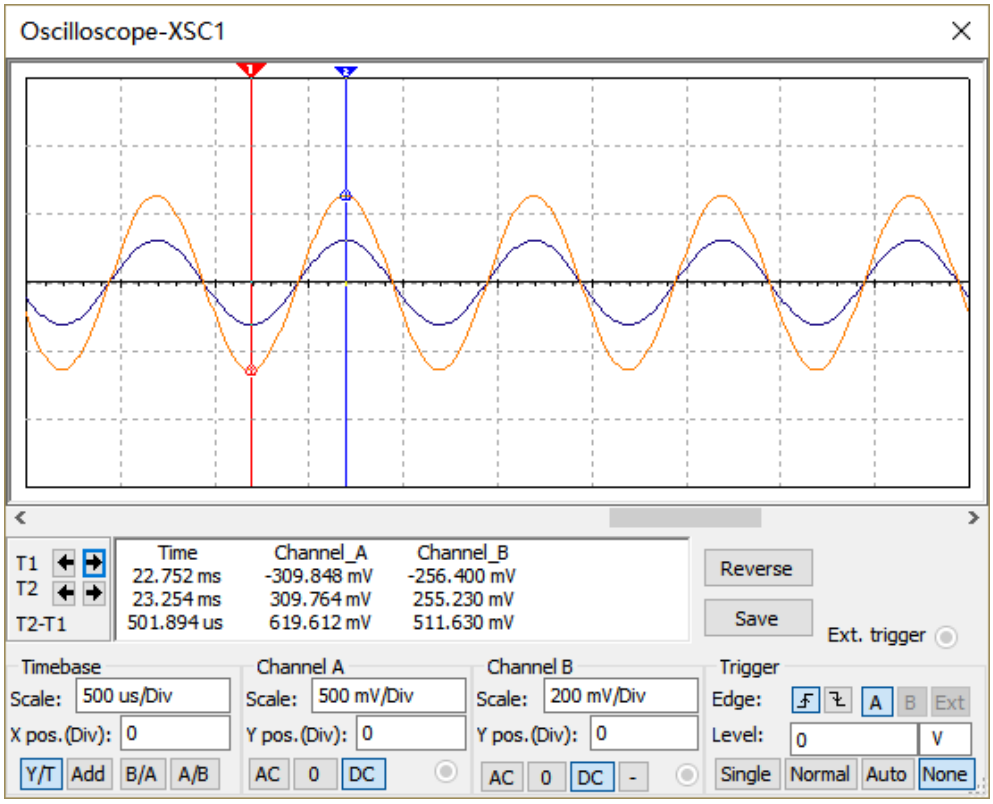


Fig.9 Bandpass filter simulation results

Input peak：309.848mv

Output peak：256.400mv

Gain：0.8275

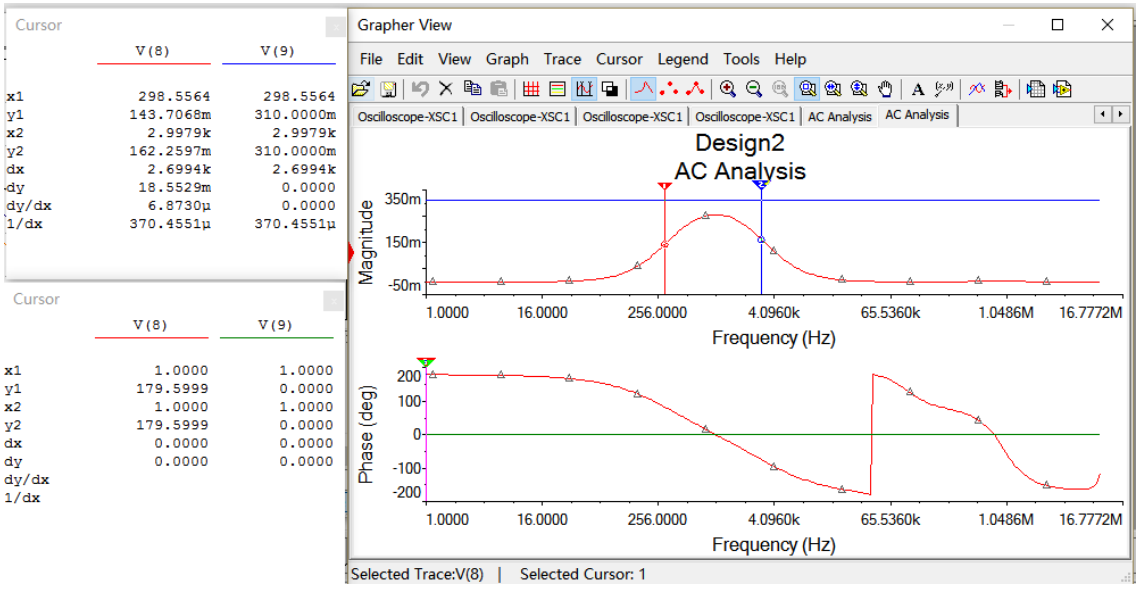


Fig.10 Bandpass filter small AC signal analysis

The passband is 300Hz~3KHz.

7.3Power amplifier

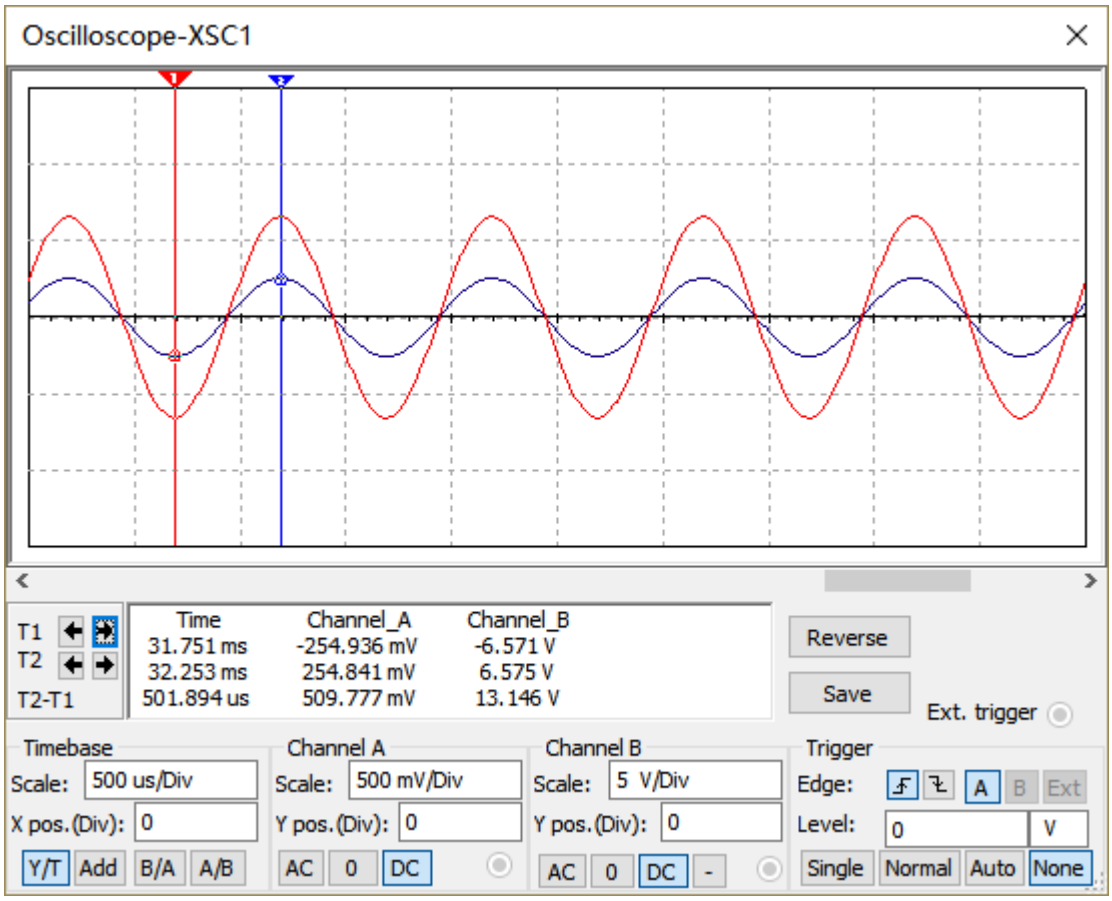


Fig.10 Power amplifier simulation results

Input peak：254.936mv

Output peak：6.571v

Gain：25.769

7.4Combine

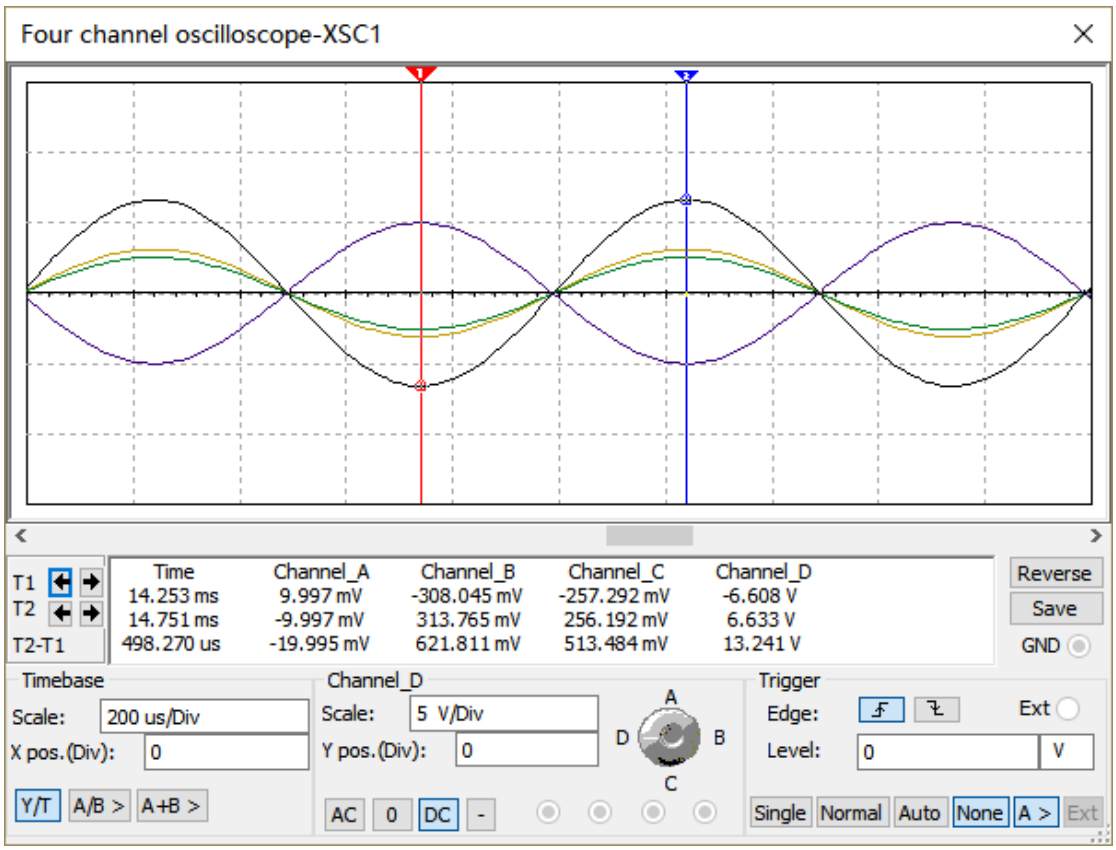


Fig.11 Simulation of overall circuits

Input peak:9.997mV

Output peak:6.608V

Gain：660.998

Maximum undistorted output power：

$Pom=Uom^2/R_L=(6.608*6.608)/(2*16)=1.36W>1W$

7.5 Comparison: measured value and required value

1. Input impedance
2. Input signal
3. CMMR
4. Passband
5. Maximum undistorted output power

$$P_{om}=U_{om}^2/R_L=$$

6. Load impedance:
7. Source voltage

Does the design satisfy the deign requirements?