# Experiment 8: Adjustment and Measurement of Power Amplifiers

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## Aim

1. Learn to adjust and measure OTL (output transformerless) power amplifier.
2. Learn to use integrated power amplifiers.

## Principle

1. An OTL power amplifier is complementary and symmetrical. In the output there is a capacitor with large capacity instead of a transformer.
2. It has the characteristic of high input resistance and low output resistance, and a low load can be connected to the output directly.
3. Strong negative feedback could be adopted to amend none linear distortion.
4. Bootstrapping circuit is used to improve output amplitude.

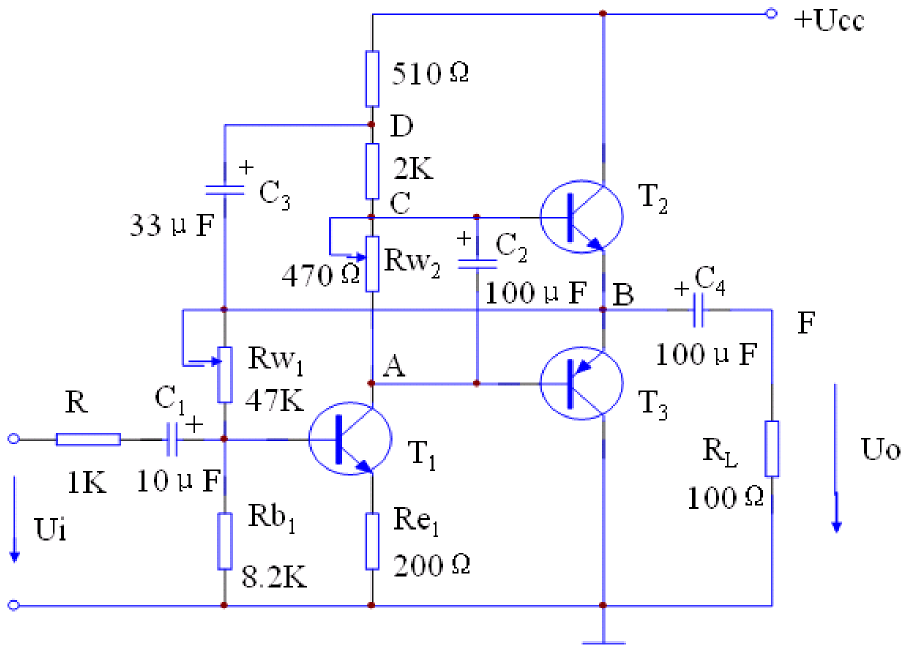
## Instruments

Digital multimeter, digital oscilloscope, DC power supply, LM386, Power amplifier PCB

## Tasks

**Tasks -OTL quiescent point adjustment**

1. Turn Rw1 and Rw2 anticlockwise to the end first.
2. Get Ucc= 12V.
3. Adjust Rw1 to make UB=6V ~ 6.5V.(make sure the current value displayed on DC power supply is less than 0.3A. Once it is more than 0.5A, switch off power at once)
4. Put dynamic signal sine wave and f=1KHz to input, and connect input and output to oscilloscope.
5. Increase Ui slowly while adjusting Rw2 to eliminate cross over distortion.
6. Measure $U_A$, $U_B$, $U_C$, $U_D$, and calculate $U_{CA}$=?




Circuit1 OTL Circuit

**Tasks –OTL AC parameters test**

1. Measure $P_{omax}$ and Av

    (1) Continue to increase input amplitude gently while watching the output wave. Once distortion waves occur, stop increasing and turn back to the state that the output is just normal.

    (2) Measure Ui and Uo, and compute $P_{omax}$ and Av.

2. Measure efficiency
3. The function of C3. Watch the waves of output with C3 and without C3. Record and compare.
4. Bootstrapping C3 improving voltage:

    (1) Measure voltage of point B, D and $U_{CC}$.

    (2) Observe waves of point F, B, D, and $U_{CC}$, and draw them together on square paper.

5. Observe current waves of $T_2$、$T_3$ on oscilloscope, record and define amplifier's working state.
6. Cross over distortion study: record wave and corresponding quiescent point $U_B$、 $U_C$ 、$U_A$, calculate $U_{CA}$ and compare with previous value.

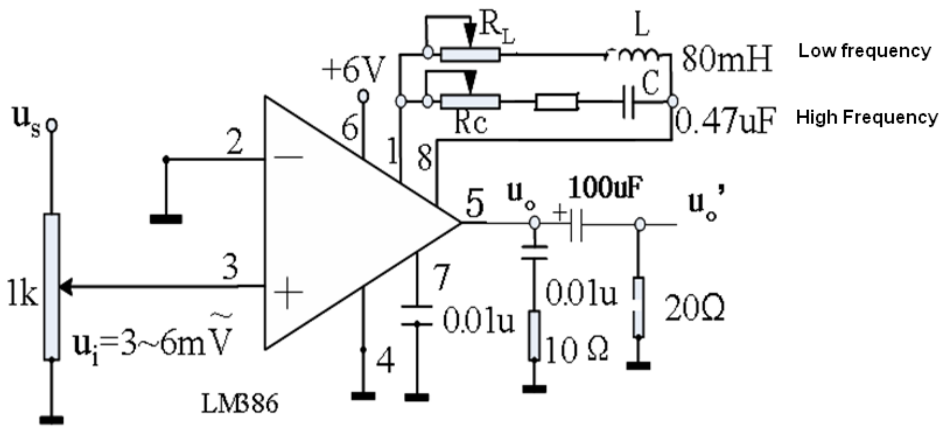
**Tasks--LM386 audio frequency power amplifier circuit**

1. Build the circuit.
2. Test the two amplitude frequency characteristics waves

    (1) $R_L$=0 Ω, $R_C$=470K Ω, measure low pass and high attenuating wave at $U_O$.

    (2) $R_L$=470K Ω,$R_C$=0 Ω measure low attenuating and high pass wave at $U_O$.

Attention: keep Ui=3~6mv, f=20HZ~20KHZ, and get 8~10 points.




Circuit2 LM386 audio frequency power amplifier circuit

# Data collation and analysis

**Task 1**

| $U_A$/V | $U_B$/V | $U_C$/V | $U_D$/V | $U_{CA}$/V |
|---|---|---|---|---|
| 4.753 | 5.970 | 7.153 | 11.067 | 2.400 |

Quiescent point is extremely important for power amplifiers. In this experiment, I adjust quiescent point for many times, and I find that the input current would increase sharply if quiescent point is not good.

**Task2**

| $U_{CC}$/V | $I_E$/A | Uip/V | Uop/V |
|---|---|---|---|
| 12.00 | 0.16 | 0.27 | 4.00 |

$$A_v = \frac{U_0}{U_i} = \frac{4.00}{0.27} = 14.81$$

$$P_{omax} = \frac{U_0^2}{R_L} = \frac{4.00^2}{2 \times 8.1} = 0.988W$$

$$\eta = \frac{p_L}{p_E} = \frac{p_{omax}}{U_{cc} \cdot I_E} = \frac{0.988}{12 \times 0.16} \times 100\% = 51.46\%$$

**Task3**

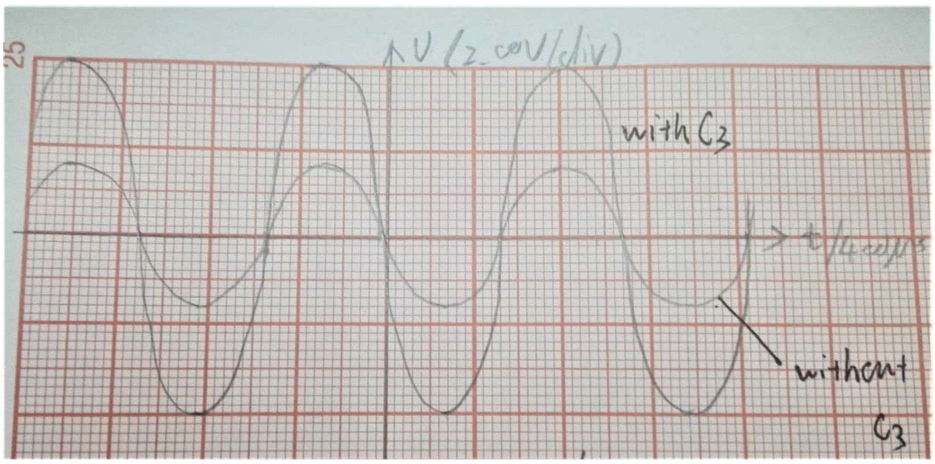


Figure 1 waveform with and without C3

The bigger waveform is with C3. The smaller waveform is without C3. From these waveform, we can conclude that, C3 can enlarge output range.

**Task4**

| $U_B$/V | $U_D$/V | $U_{VCC}$/V |
|---|---|---|
| 5.978 | 11.087 | 12.058 |

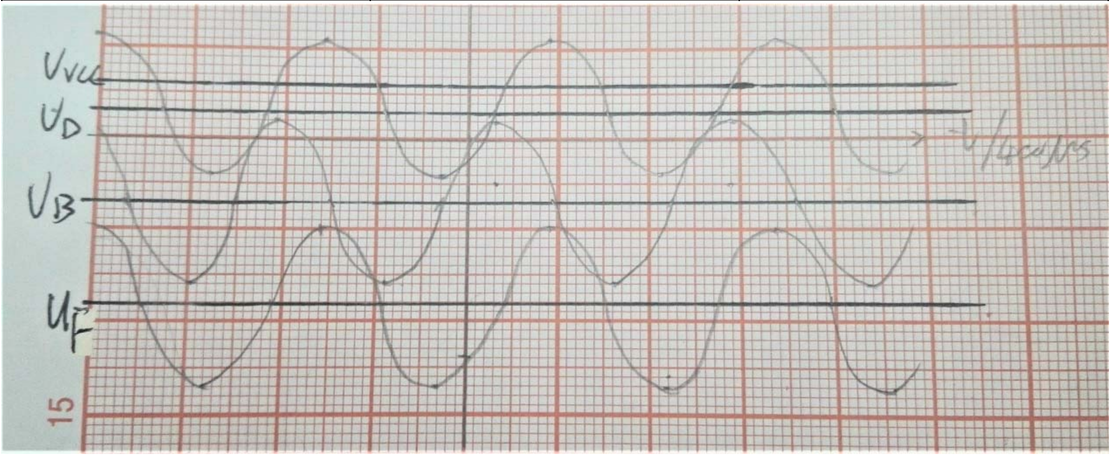



Figure 2 waveform with and without C3

From figure2, the waveform of $U_D$ can be higher than VCC, as the result of capacity C3.

**Task 5**

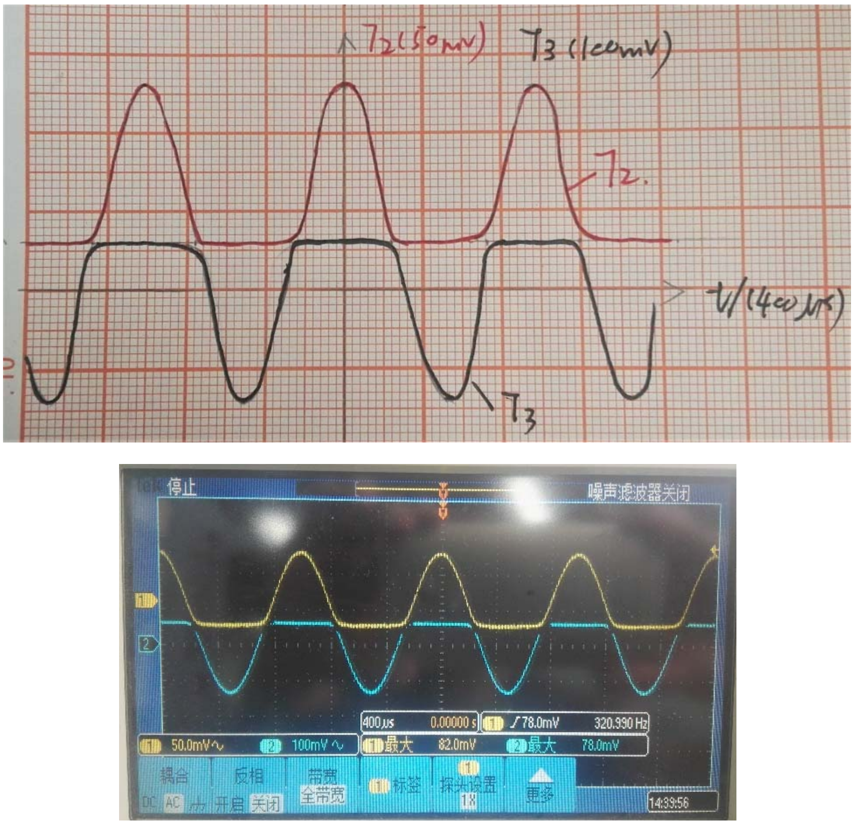
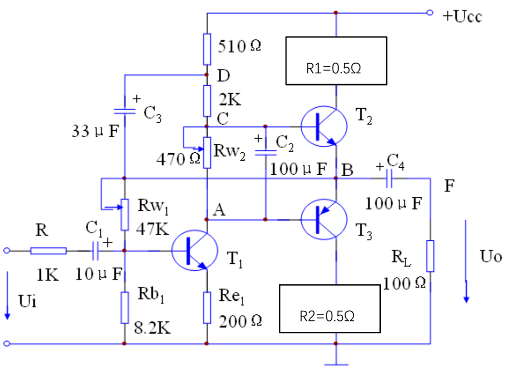



Figure 3 Current waves of T2、T3

The range of T3 is twice of the range of T2. When the waveform is a straight line, triode works in cut-off state; when the waveform is semi-sin-wave, triode works in enlargement state. To explain why the range of two triodes are different is a little difficult. But clever as I still figured it out.




When turn to positive half cycle, Uo is high, so current of RL is high, then voltage on R1 is high. As the result, peak voltage is far lower than original peak voltage.

But when turn to negative half cycle, Uo is low, so voltage on R2 is low. As the result, bottom voltage is a little higher than original bottom peak.

That's the reason why the range is different.

**Task 6**

| $U_B$/V | $U_C$/V | $U_A$/V | $U_{CA}$/V |
|---|---|---|---|
| 6.050 | 7.063 | 5.134 | 1.929 |

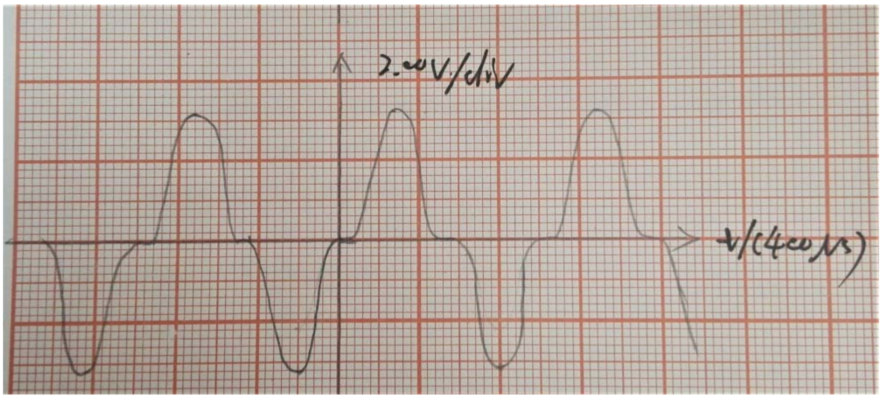




Figure 4 Waveform of cross over distortion

$U_{CA}$ is less than 2.8V, so there must be cross over distortion.

**Task 7**

Ui=4.5mV  I measured output voltage and recorded as follow:

| $R_L$=0Ω  $R_C$=470kΩ | | | | | | | |
|---|---|---|---|---|---|---|---|
| f(Hz) | 50 | 100 | 300 | 400 | 500 | 600 | 700 |
| 20lgf(dB) | 33.98 | 40.00 | 49.54 | 52.04 | 53.98 | 55.56 | 56.90 |
| $U_{op}$(mV) | 650 | 650 | 610 | 550 | 550 | 490 | 470 |
| Uo(mV) | 33.98 | 40.00 | 49.54 | 52.04 | 53.98 | 55.56 | 56.90 |
| f(Hz) | 730 | 800 | 900 | 1000 | 1500 | 2000 | 3000 |
| 20lgf(dB) | 57.27 | 58.06 | 59.08 | 60.00 | 63.52 | 66.02 | 69.54 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $U_{op}$(mV) | 450 | 430 | 410 | 370 | 310 | 270 | 270 |
| Uo(mV) | 57.27 | 58.06 | 59.08 | 60.00 | 63.52 | 66.02 | 69.54 |
| $R_L$=470Ω $R_C$=0kΩ | | | | | | | |
| f(Hz) | 80 | 150 | 250 | 350 | 450 | 800 | 1300 |
| 20lgf(dB) | 38.06 | 43.52 | 47.96 | 50.88 | 53.06 | 58.06 | 62.28 |
| $U'_{op}$(mV) | 90 | 110 | 110 | 130 | 130 | 150 | 130 |
| $U'_{o}$(mV) | 38.06 | 43.52 | 47.96 | 50.88 | 53.06 | 58.06 | 62.28 |
| f(Hz) | 2000 | 3000 | 3100 | 4000 | 5000 | 7000 | 10000 |
| 20lgf(dB) | 66.02 | 69.54 | 69.83 | 72.04 | 73.98 | 76.90 | 80.00 |
| $U'_{op}$(mV) | 230 | 390 | 330 | 370 | 410 | 410 | 450 |
| $U'_{o}$(mV) | 66.02 | 69.54 | 69.83 | 72.04 | 73.98 | 76.90 | 80.00 |

I plot the two amplitude frequency characteristic curves as figure 4:

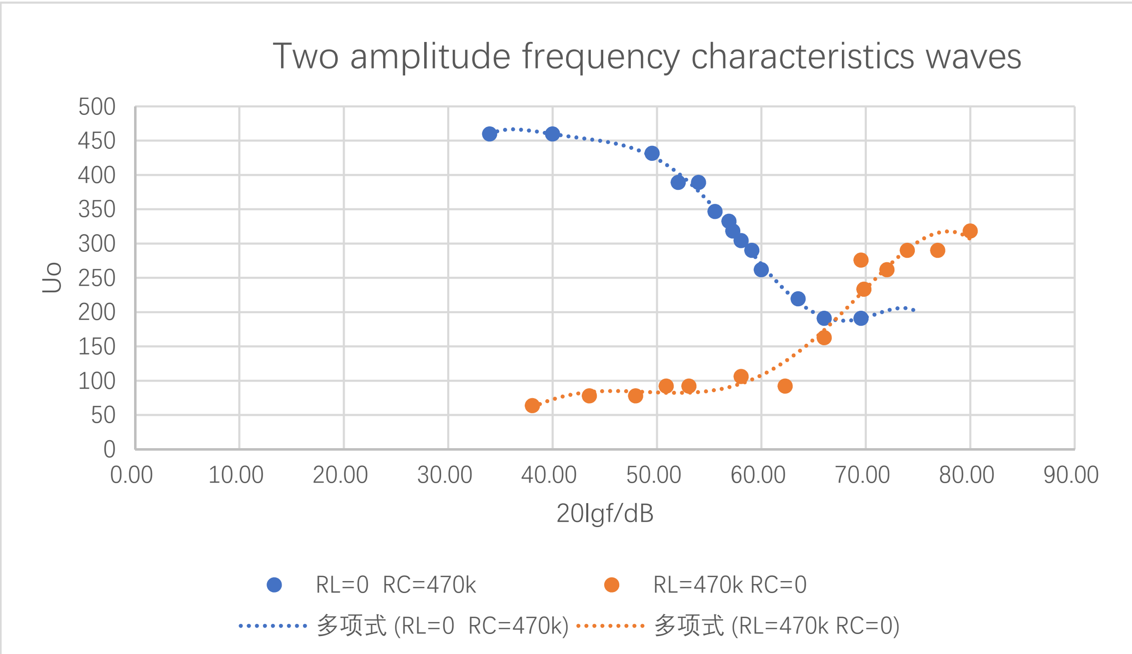



Figure 5 two amplitude frequency characteristic curves

# Summary

I studied power amplifier through this experiment. The reason of cross over distortion is: when quiescent point is not suitable, input voltage plus quiescent voltage is too small to make triode work in enlargement area, so the initial part of sin wave becomes a straight line.