電子電路實驗 3,4：CMOS Operational Amplifier

實驗預報

B02901178 江誠敏

September 22, 2015

1 Objectives

1. To make sure all the MOS of the circuit are able to enter saturation region so that the circuit can be applied to be an operational amplifier.

2. To comprehend the method of eliminating the Crossover Distortion of a class-B output stage.

2 Procedures

2.1 DC Analysis

2.1.1 DC Analysis of CD4007

1. The condition of entering saturation region of NMOS: $V_{GD} \le V_T(1.8\,\mathrm{V})$.
2. The condition of entering saturation region of PMOS: $V_{GD} \ge V_T(-1.8\,\mathrm{V})$.
3. Supply voltage $-V_{SS} = -8\,\mathrm{V}$ and $V_{DD} = +8\,\mathrm{V}$ to the circuit.
4. Provide voltage source $V_{CC} = +15V$, and $-V_{CC} = -15V$ to the circuit.
5. Use digital multi-meter to confirm whether all of the MOS components are able to enter saturation region as adjusting VR $1\,\mathrm{k}\Omega$.

2.1.2 Detail procedure of DC Analysis of the Two-stage OP-Amp circuit

1. adjust VR $R_2 = 10\,\mathrm{k}\Omega$ and check whether (Q_5, Q_7, Q_8) are all able to enter saturation region, that is, $V_{GD5,7,8} \ge V_T$ (–1.8V). If one of them is not so, change the chip of CD4007 #A and recheck again.

2. Use multi-meter to measure $V_{GD5}, V_{GD7}, V_{GD8}$.

3. adjust VR $R_2 = 10\,\mathrm{k}\Omega$ and check whether (Q_1, Q_2) are all able to enter saturation region, that is, $V_{GD1,2} \geq V_T$ (−1.8V). If one of them is not so, change the chip of CD4007 #B and recheck again.
4. Use multi-meter to measure V_{GD1}, V_{GD2}.
5. In Fig.5, Use heck whether (Q_3, Q_4) are all able to enter saturation region, that is, $V_{GD3,4} \geq V_T$ (−1.8V). If one of them is not so, change the chip of CD4007 #C and recheck again.
6. Use multi-meter to measure V_{GD3}, V_{GD4}.

2.1.3 DC Analysis of the Two-stage OP-Amp circuit

1. In Fig. 6, adjust VR (R_3) $1\,\mathrm{k}\Omega$ and use multi-meter to measure V_A and V_E , and check whether V_E is adjustable. If it not so , trouble shoot the circuit. Check whether there is any wrong layout in your breadboard and whether the VR (R_3) is functional by multimeter.
2. Record V_A, V_E.

2.1.4 Circuit implementation

1. In Fig. 2, adjust VR (R_3) $1\,\mathrm{k}\Omega$ and use multi-meter to measure V_A, V_D, V_E, V_F

2.2 Small-signal Analysis

2.2.1 Voltage Gain

1. Adjust VR (R_3) in Fig. 3 to have $V_F \approx 0$.
2. In Fig 4, apply the input small signal V_i to the breadboard by using function generator to generate $v_i = v_{ac}\sin(2\pi f t), 2v_{ac} = 20mV_{p-p}, f = 1\,\mathrm{kHz}$.
3. Make sure that the v_i is measured from the breadboard by using the probe from `CH1` in oscilloscope.
4. Oscilloscope ▷`YT mode`.
5. Adjust VR (R_3) $1\,\mathrm{k}\Omega$ in Fig. 2-2 to have maximum small-signal voltage gain V_F/V_i .
6. Keep the previous adjustment of R_3 constantly.
7. Record the voltage gain A_M.
8. Record the V_F, R_3.
9. Confirm whether the voltage gain is the same as the slope of teh curve at transition region measured in the step 6 at Exp 3.
10. Increase/Decrease V_i until the waveform of V_F just distort.
11. Record the peak-to-peak value of V_i.

2.2.2 Frequency Response

1. Set $v_i = v_{ac}\sin(2\pi ft), 2v_{ac} = 20\,\mathrm{mV}_{p-p}, f = 1\,\mathrm{kHz}$.
2. Function generator ▷Adjust Frequency and observe the voltage gain A_v in oscilloscope until $A_v = \sqrt{2}A_M$.
3. Record the frequency f_{3db}.
4. Change the frequency of input voltage source, and record the input and output voltage shown in oscilloscope.

2.2.3 Internal frequency compensation

1. Use $R_2 = 100\,\mathrm{k\Omega}, C_2 = 10\,\mathrm{pF}$ in to implement the compensation circuit in Fig. 5.
2. Record the voltage gain $A_{M,2}$, dynamic range V_i , and frequency $f_{3dM,2}$.

2.2.4 Feedback network compensation

1. Use $R_2 = 100\,\mathrm{k\Omega}, C_2 = 10\,\mathrm{pF}$ in to implement the compensation circuit in Fig. 3.
2. In Fig. 6, apply the input small signal V_i to the breadboard by using function generator to generate $v_i = v_{ac}\sin(2\pi f_t), 2v_{ac} = 100\,\mathrm{mV}_{p_p}, f = 1\,\mathrm{kHz}$.
3. Record the voltage gain $A_{M,2}$, dynamic range V_i , and frequency $f_{3dM,2}$.