2024.6.5 13:20-15:10pm

電子學（二）期末考 Chapter 10, 11, 12.1~12.3,13.2

(if not specified, $v_d = v_1 - v_2$, $v_{cm} = (v_1 + v_2)/2$ for differential amplifiers)

必須要有計算過程。

1. (10%) For the current-source circuit shown in Figure 1, assume $V_{BE1}(\text{on}) = 0.7$ V, $\beta = 40$, $V^+ = 5$ V, $V^- = -5$ V, and all base currents are NOT negligible. (a) Design I_{REF} such that $I_O = 0.1$ mA. (b) Assuming that $V_A = 80$ V, what is the output resistance R_O of this circuit?

2. (10%) For the circuit in Figure 2, the transistor parameters are: $K_p = 0.1\ \text{mA/V}^2$, $K_n = 0.25\ \text{mA/V}^2$, $V_{TN} = 1$ V, $V_{TP} = -1$ V, $\lambda_n = 0.01\ \text{V}^{-1}$, and $\lambda_p = 0.02\ \text{V}^{-1}$. Let $V^+ = 10$ V, $I_{REF} = 0.25$ mA, and $R_L = 500$ kΩ. (a) Find the small-signal voltage gain $A_v = v_o/v_i$. (b) If transistors M1-M2 are replaced by cascode active load (with same transistor parameters), find the new small-signal voltage gain $A_v = v_o/v_i$.

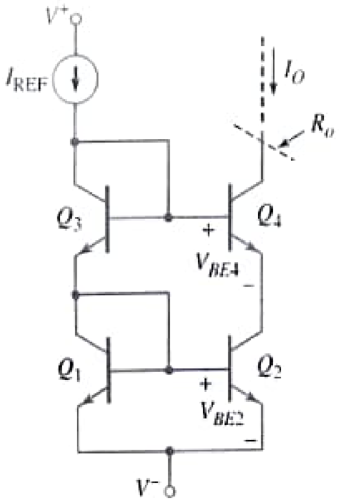

Figure 1

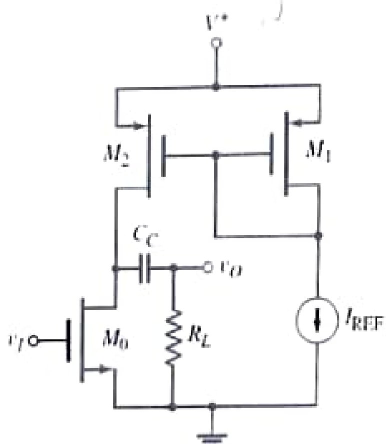

Figure 2

3. (12%) Consider the BiCMOS Darlington pair in Figure 3. The NMOS parameters are $K_n = 50\ \mu\text{A/V}^2$, $V_{TN} = 0.5$ V, and $\lambda = 0$. The BJT parameters are $\beta = 150$, $V_{BE}(\text{on}) = 0.7$ V, and $V_A = \infty$. (a) Determine the transconductance for each transistor (g_{m1} and g_{m2}) (4%). (b) Determine the composite transconductance $g_m{}^c = i_o/v_i$ (5%). (c) What is the advantage of this circuit comparing to a MOSFET alone (3%)?

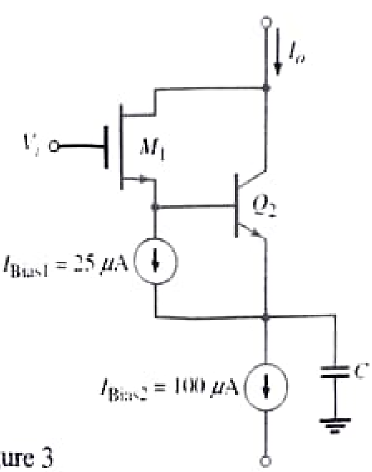

Figure 3

4. (20%) For the differential amplifier shown in Figure 4, the parameters are $R_1 = 50\ \text{k}\Omega$ and $R_D = 24\ \text{k}\Omega$. The transistor parameters are $K_n = 0.25\ \text{mA/V}^2$, $V_{TN} = 2\ \text{V}$, and $\lambda = 0$. (a) Determine I_Q (4%). (b) What are the maximum and minimum values of common-mode input voltage v_{CM} (6%). (c) Determine the differential-mode gain $A_d = v_o/v_d$ (5%). (d) If $\lambda = 0.02\ \text{V}^{-1}$ for M_3 and M_4, determine the common-mode gain $A_{cm} = v_o/v_{cm}$ (5%).

5. (25%) Consider the Darlington pair and output stage of the circuit in Figure 5. The parameters are $I_{C7} = I_Q = 0.5\ \text{mA}$, $I_{C8} = 2.5\ \text{mA}$, $R_4 = 5\ \text{k}\Omega$, $R_2 = R_3 = 0.1\ \text{k}\Omega$, $\beta = 100$ for all transistors, and early voltages $V_A = 80\ \text{V}$ for Q_1~ Q_5 and Q_{11}. (a) Determine the input resistance of the Darlington pair R_i. (b) Determine the resistance looking into collector of Q_{11}. (c) Calculate the small-signal voltage gain of the differential amplifier ($A_{v1} = v_{o2}/v_d$). (d) Calculate the small-signal voltage gain of the Darlington pair ($A_{v2} = v_{o3}/v_{o2}$). (e) Find the output resistance (R_o).

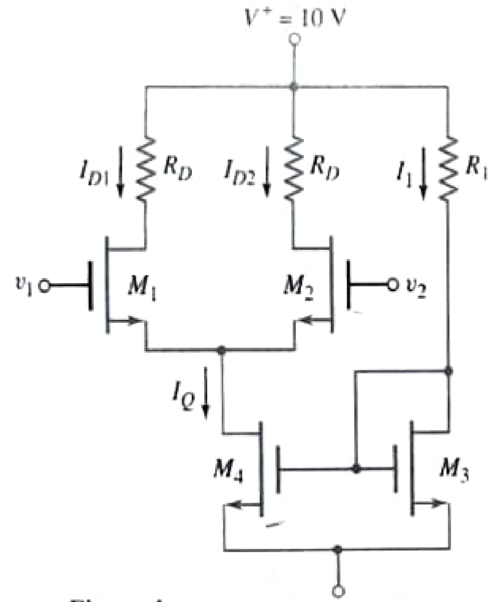

Figure 4

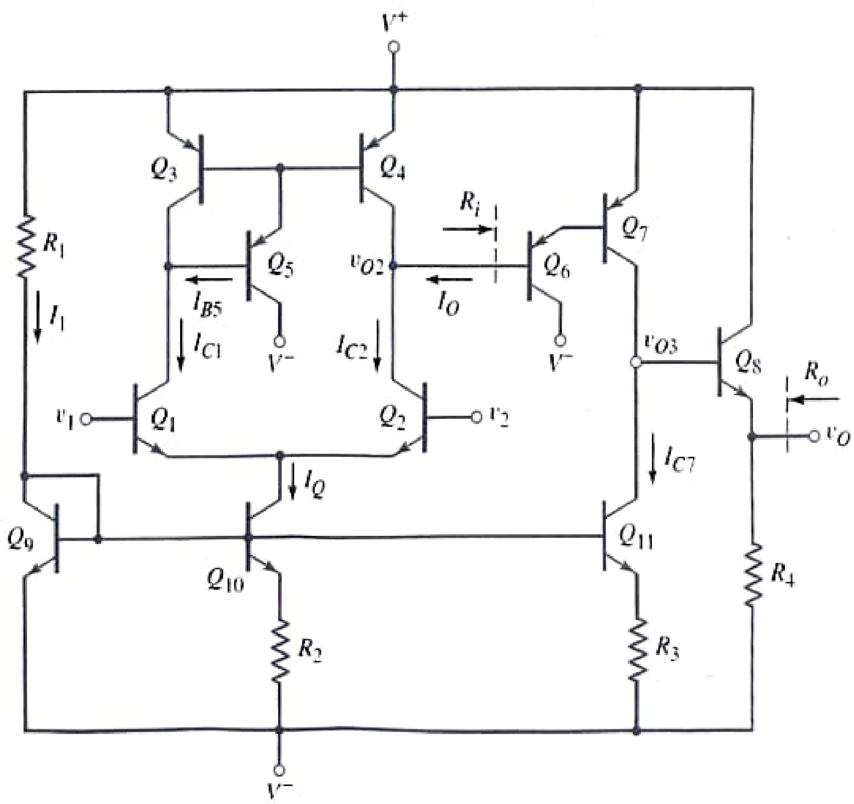

Figure 5

6. (10%) For a feedback system shown in Figure 6, the amplifier A has input resistance R_i and output resistance R_o. (a) What kind of feedback system is this (4%)? (b) What are the input resistance R_{if} and output resistance R_{of} of the entire system (6%)?

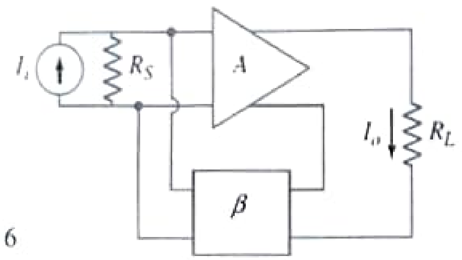

Figure 6

7. (13%) uA741 circuit is shown in Figure 7. In the classroom, we have analyzed uA741 assuming $V^+ = 15V$ and $V^- = -15V$. (a) Writing down the equation of input resistance of gain stage R_{i2} using β_n, β_p, g_m, r_π of Q_{16}~Q_{17} and necessary resistors (5%). (b) What is the purpose or function for the combination of Q_{18}, Q_{19} and R_{10} (4%)? (c) What is the purpose or function for the combination of Q_{15}, Q_{21}, R_6 and R_7 (4%)?

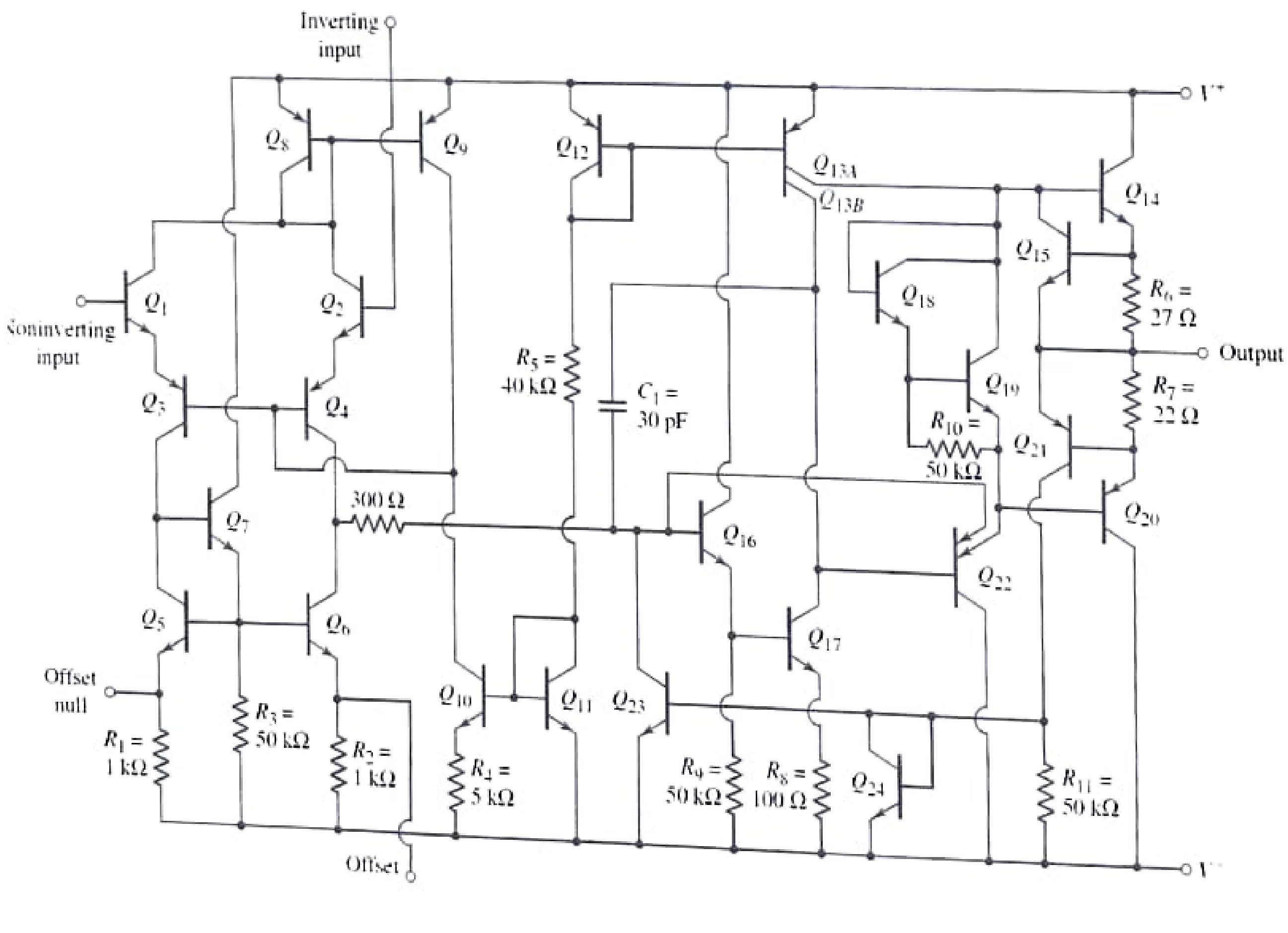

Figure 7