

# 991 Microelectronic Circuits I (Final Exam)

date: 2011/01/13 (Thur)

time: 15:30 ~ 17:20

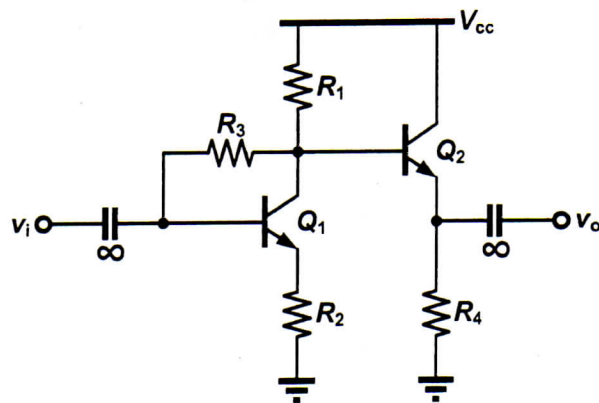
ps. 試題可帶回，可使用計算機。

1. The circuit parameters are given as:

$V_{CC} = 20\text{ V}$ ,  $R_1 = 10\text{ k}\Omega$ ,  $R_2 = 1\text{ k}\Omega$ ,  $R_3 = 200\text{ k}\Omega$ ,  $R_4 = 8\text{ k}\Omega$ , and  $\beta = 50$ .

(a) Based on dc analysis, find the values of  $I_{C1}$  and  $I_{C2}$ . (10%)

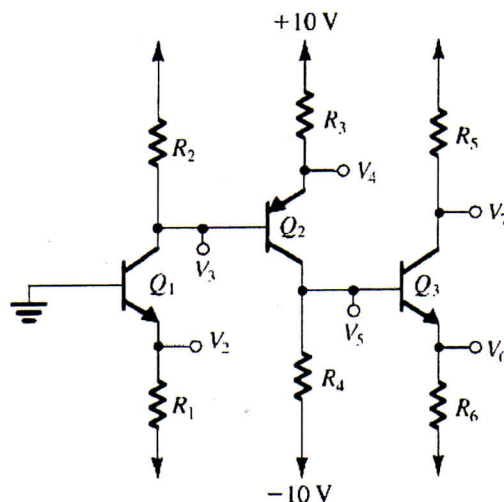
(b) What is the small-signal gain of  $v_o/v_i$ ? (13%)



2. For the following circuit,

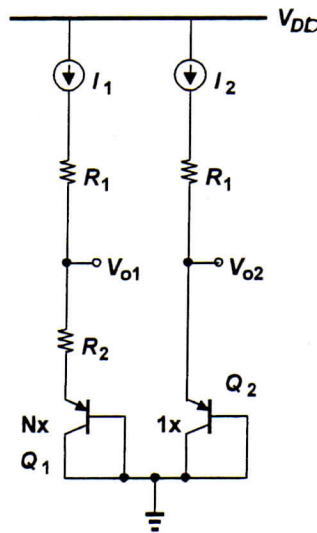
(a) Using  $\beta$  is infinite, design the circuit so that the bias currents in  $Q_1$ ,  $Q_2$ , and  $Q_3$  are 2mA, 2mA, and 4mA, respectively, and  $V_3 = 0$ ,  $V_5 = -4\text{V}$ , and  $V_7 = 2\text{V}$ . (5%)

(b) Now, for  $\beta = 30$ , find the values of  $V_3$ ,  $V_4$ ,  $V_5$ ,  $V_6$ , and  $V_7$ . (5%)



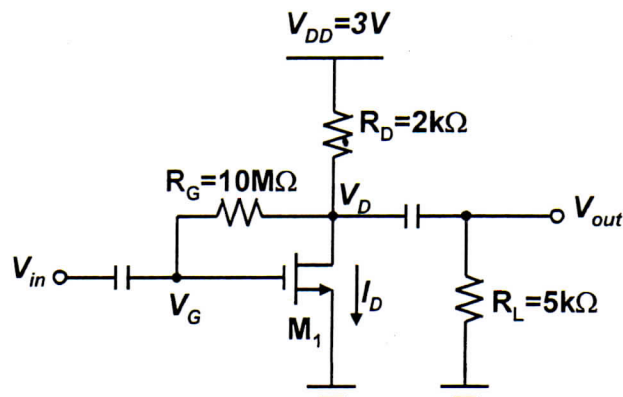
3. For the following circuits, let's assume we can use some circuit to generate  $I_1$  and  $I_2$  such that  $I_1=I_2$  and  $V_{o1}=V_{o2}$ . Also, the emitter size of  $Q_1$  is  $N$  times larger than that of  $Q_2$ .

- What's the value of  $I_1$ ? Express the answer in terms of  $V_T=(kT/q)$  and  $N$ . (6%)
- Express  $V_{o1}$  in terms of  $V_T$  and  $V_{BE1}$ . For a given current  $I_1$ , what's the temperature coefficient of  $V_{o1}=(dV_{o1}/dT)$ ? Is it possible to obtain zero temperature coefficient for  $V_{o1}$ ? If so, what's the condition? (10%)
- Now, due to some noise perturbation  $I$  at  $I_1$  so that some voltage perturbation  $V$  appears at  $V_{o1}$ . Express  $V$  in terms of  $I$ ,  $R_1$ ,  $R_2$  and  $N$ . (6%)



4. For the amplifier circuit shown below, the NMOS transistor has the following parameters:  $W/L = 0.9\text{m}/0.18\text{m}$ ,  $\mu_n C_{ox} = 1600\text{A/V}^2$ , threshold voltage  $V_{TN} = 0.5\text{ V}$ , and  $V_A = 10\text{ V}$ . Both capacitors are coupling capacitors.

- Calculate the DC operation point of the amplifier (find  $V_G$ ,  $V_D$ , and  $I_D$ ). (7%)
- Find the amplifier gain ( $V_{out}/V_{in}$ ). (7%)
- If the resistor  $R_G$  is changed to  $10\text{ k}$ , how does this affect the DC operating point? What is the amplifier gain ( $V_{out}/V_{in}$ ) now? (9%)



5. Consider the PMOS common-gate circuit in the following circuit. The transistor parameters are:  $V_{TP} = -1V$ ,  $K_p = 0.5 \text{ mA/V}^2$ , and  $\lambda = 0$ .

- Determine  $R_S$  and  $R_D$  such that  $I_D = 0.5 \text{ mA}$  and  $V_{SD} = 6V$ . (6%)
- Determine the input impedance  $R_i$  and the output impedance  $R_o$ . (6%)
- Determine the load current  $i_o$  and the output voltage  $v_o$ , if  $i_i = 5\sin(\omega t) \mu\text{A}$  (10%).

