國立臺北科技大學九十七學年度碩士班招生考試

系所組別：2401 光電工程系碩士班不分組

第三節　電子學（選考）試題

填 准 考 證 號 碼

注意事項：

1. 本試題共七題，配分共 100 分。
2. 請標明大題、子題編號作答，不必抄題。
3. 全部答案均須在答案卷之答案欄內作答，否則不予計分。

1. (10%) Fig. 1 shows an op amp that is ideal except having a finite open-loop gain A is used to realize an inverting amplifier whose gain has a nominal magnitude $G=R_2/R_1$.

(1) Derive the gain of the inverting amplifier. (4%)

(2) To compensate for the gain reduction due to the finite A, a resistor R_c is shunted across R_1. Show that perfect compensation is achieved when R_c is selected according to $R_c/R_1=(A-G)/(1+G)$. (6%)

2. (10%) The circuit in Fig. 2 provides a constant current I_O when the circuit to which the collector is connected maintains the BJT in the active mode. Show that

$$I_O = \alpha \frac{V_{CC}[R_2/(R_1+R_2)]-V_{BE}}{R_E+(R_1 \parallel R_2)/(\beta+1)}$$

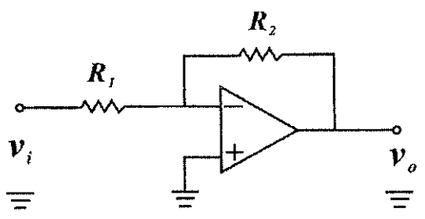

Fig. 1

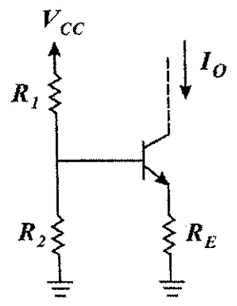

Fig. 2

3. (10%) By Miller's theorem, an impedance Z connected between two isolated circuit nodes, labeled 1 and 2, can be replaced by two impedances Z_1 and Z_2 when the voltages at node 1 and 2 have the relation of $V_2 = K \cdot V_1$.

(1) Please sketch the Miller equivalent circuit and describe the details of Miller's theorem. (4%)

(2) Derive the equations for Z_1 and Z_2. (6%)

4. (15%) Fig. 4 shows the Wilson bipolar current mirror. These BJTs have the device parameters of β, r_o, and r_e. Please derive the current transfer ratio (7%) and the output resistance (8%).

5. (15%) Fig. 5 shows the common-gate amplifier with the load resistance R_L. Consider the body effect and the effect of r_o.

(1) Find the input resistance R_{in} (5%) and the output resistance R_{out} (5%).

(2) Find the voltage gain A_v (5%).

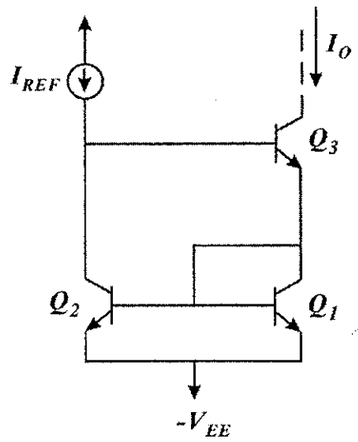

Fig. 4

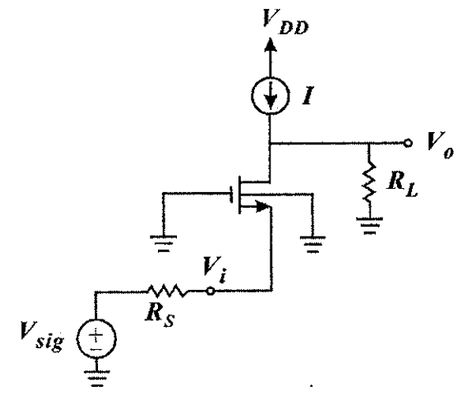

Fig. 5

6. (20%) A BJT differential amplifier operating with a 2-mA current source uses transistors for which β =100, f_T=637MHz, C_μ=1pF, and r_x=100Ω. Each of the collector resistances is 20kΩ and r_o is very large. The amplifier is fed in a symmetrical fashion with a source resistance of 10kΩ in series with each of the two input terminals.

(1) Determine the low-frequency value of the overall differential gain. (8%)

(2) Use Miller's theorem to determine the input capacitance, and hence estimate the 3-dB frequency f_H and the gain-bandwidth product. (12%)

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7. (20%) The circuit shown in Fig. 7 consists of a differential stage followed by an emitter follower with feedback.

(1) Assume that the dc component of V_s is zero and that β of the BJTs is very high. Find the dc operating current of each of the three transistors and the dc voltage at the output . (5%)

(2) Assume that the transistors have β =100. Find the values of A, β, $A_f \equiv V_o/V_s$, R_{in}, and R_{out}. (15%)

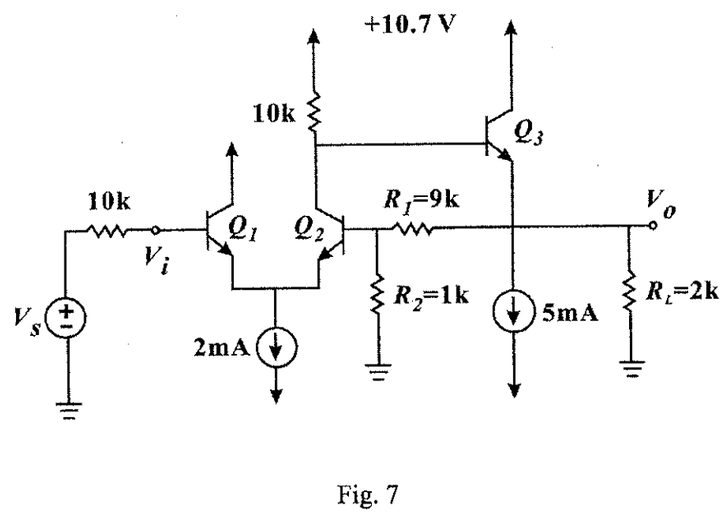

Fig. 7