

國立勤益科技大學 101 學年度研究所碩士班招生筆試試題卷

所別：電子工程系 碩士班

組別：電子組

科目：電子學

准考證號碼：□□□□□□□□ (考生自填)

考生注意事項：

一、考試時間 100 分鐘。

二、應考人不得自行攜帶電子計算器，一律由本校統一提供

三、

試題一：〈 15 分 〉

A BJT (Bipolar Junction Transistor) having $\beta=100$ is biased at a dc collector current of 1mA. Find the value of g_m , r_e , and r_π at the bias point.

試題二：〈 20 分 〉

Given a circuit shown in Fig.1 has $v_{i1} = 2V$, $v_{i2} = 4V$, $R_1=50\text{ k}$, $R_2=100\text{ k}$, $R_3=20\text{ k}$, and $R_4=100\text{ k}$. Find the differential output voltage v_o (15%) and the differential input resistance R_{id} (5%).

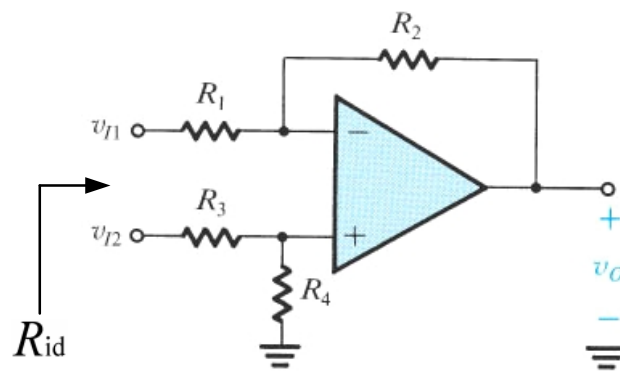


Fig. 1

試題三：〈 15 分 〉

Determine the voltage gain, input, and output impedance with feedback for Series-Shunt feedback circuit having $A=-100$, $R_i=10\text{ k}$, $R_o=20\text{ k}$, and $\beta=-0.1$.

試題四：〈20分〉

A BJT circuit shown in Fig.2 has $\beta=100$. Find the value of I_B , I_C , I_E , V_B , and V_C .

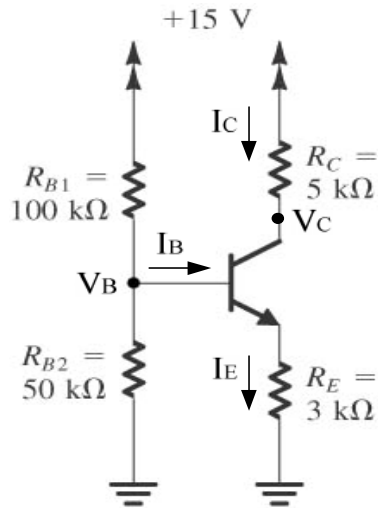


Fig. 2

試題五：〈20分〉

Fig.3 shows the common-source amplifier. Draw ac small signal equivalent circuit (8%). Find voltage gain $A_v = v_o/v_i$ (4%), overall voltage gain $G_v = v_o/v_{sig}$ (4%), input resistance R_{in} (2%), and output resistance R_{out} (2%). (note: $r_o=0$)

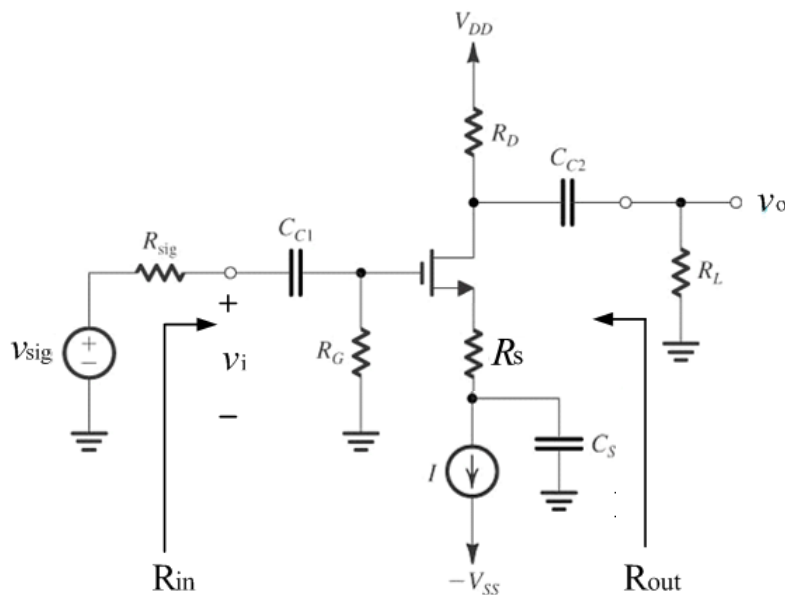


Fig. 3

試題六：〈 10 分 〉

A NMOS FET has $\mu_n C_{ox} = 100 \mu\text{A}/\text{V}^2$, $W/L = 40$, $V_t = 1\text{V}$, and $V_A = 10\text{V}$. Find g_m and r_o when $V_{GS} = 2\text{V}$.

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試題一：〈 15 分 〉

A BJT (Bipolar Junction Transistor) having $\beta=100$ is biased at a dc collector current of 1mA. Find the value of g_m , r_e , and r_π at the bias point.

$$g_m = \frac{I_C}{V_T} = \frac{1\text{mA}}{25\text{mV}} = 40\text{mA/V} \quad (5\%)$$

$$r_e = \frac{\alpha}{g_m} \approx \frac{1}{g_m} = 25\Omega \quad (5\%)$$

$$r_\pi = r_e(1 + \beta) \approx 2.5\text{k} \quad (5\%)$$

試題二：〈 20 分 〉

Given a circuit shown in Fig.1 has $v_{I1} = 2V$, $v_{I2} = 4V$, $R_1=50\text{ k}$, $R_2=100\text{ k}$, $R_3=20\text{ k}$, and $R_4=100\text{ k}$. Find the differential output voltage v_o (15%) and the differential input resistance R_{id} (5%).

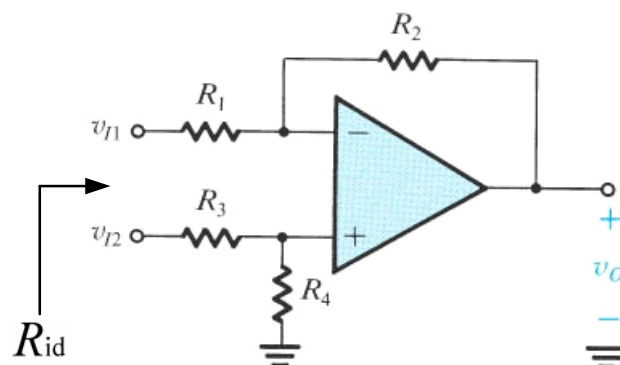
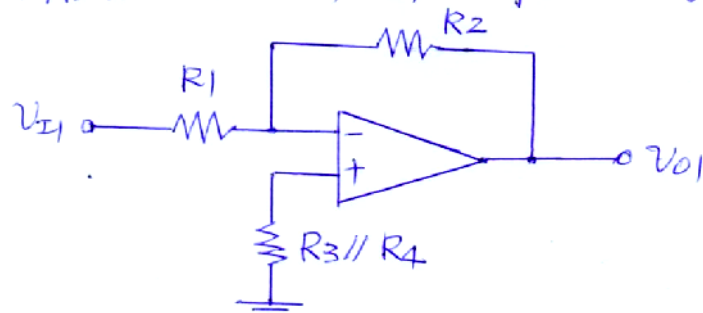


Fig. 1

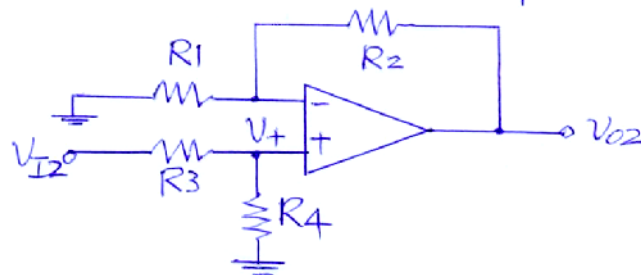
Sol. : —, $V_0 = V_{01} + V_{02}$

1. Assume $V_{I2} = 0$, $V_{I1} = \text{input} \Rightarrow \text{find } V_{01}$



$$V_{01} = -\frac{R_2}{R_1} V_{I1}$$

2. Assume $V_{I1} = 0$, $V_{I2} = \text{input} \Rightarrow \text{find } V_{02}$



$$\therefore V_+ = \frac{R_4}{R_3 + R_4} V_{I2}$$

$$\begin{aligned} \therefore V_{02} &= \left(1 + \frac{R_2}{R_1}\right) V_+ \\ &= \left(1 + \frac{R_2}{R_1}\right) \frac{R_4}{R_3 + R_4} V_{I2} \end{aligned}$$

3. $V_0 = V_{01} + V_{02}$

$$\begin{aligned} &= -\frac{R_2}{R_1} V_{I1} + \left(1 + \frac{R_2}{R_1}\right) \frac{R_4}{R_3 + R_4} V_{I2} \\ &= -\frac{100K}{50K} \times 2V + \left(1 + \frac{100K}{50K}\right) \frac{100K}{20K + 100K} \times 4V \\ &= -4V + 10V \\ &= 6V \end{aligned}$$

$$\begin{aligned} \therefore R_{id} &= R_1 + R_3 \\ &= 50K + 20K \\ &= 70K \Omega \end{aligned}$$

試題三：〈 15 分 〉

Determine the voltage gain, input, and output impedance with feedback for Series-Shunt feedback circuit having $A=-100$, $R_i=10k$, $R_o=20k$, and $\beta=-0.1$.

$$D = 1 + \beta A = 1 + (-0.1)(-100) = 11$$

$$A_f = \frac{A}{D} = \frac{-100}{11} = -9.09 \quad (5\%)$$

$$Z_{if} = Z_i \cdot D = 10k\Omega \cdot 11 = 110k\Omega \quad (5\%)$$

$$Z_{of} = Z_o / D = 20k\Omega / 11 = 1.82k\Omega \quad (5\%)$$

試題四：〈 20 分 〉

A BJT circuit shown in Fig.2 has $\beta=100$. Find the value of I_B , I_C , I_E , V_B , and V_C .

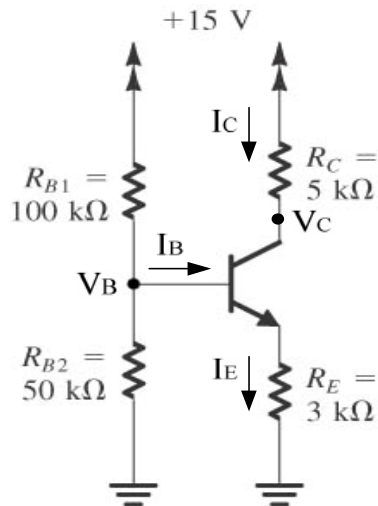
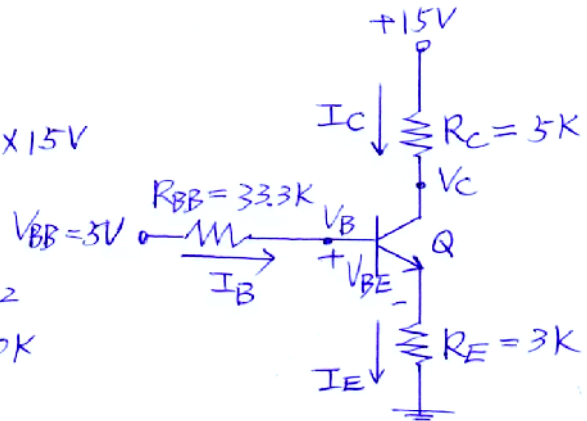


Fig. 2

Sol. : —

$$1. V_{BB} = \frac{R_{B2}}{R_{B1} + R_{B2}} \times 15V$$
$$= 5V$$

$$2. R_{BB} = R_{B1} \parallel R_{B2}$$
$$= 100K \parallel 50K$$
$$= 33.3K$$



∴ Assume Q in active mode:

$$1. V_{BB} = I_B R_{BB} + V_{BE(ON)} + I_E R_E$$
$$= \left(\frac{I_E}{\beta + 1} \right) R_{BB} + 0.7V + I_E R_E$$

$$\Rightarrow I_E = \frac{V_{BB} - 0.7}{R_E + \left[\frac{R_{BB}}{\beta + 1} \right]}$$
$$= 1.29 \text{ mA}$$

$$2. I_B = \frac{I_E}{\beta + 1} = \frac{1.29 \text{ mA}}{101} = 0.0128 \text{ mA}$$

$$3. I_C = \beta I_B = 100 \times 0.0128 \text{ mA} = 1.28 \text{ mA}$$

$$4. V_B = V_{BE} + I_E R_E$$
$$= 0.7 + 1.29 \text{ mA} \times 3K$$
$$= 4.57 \text{ V}$$

$$5. V_C = 15V - I_C R_C$$
$$= 15 - 1.28 \text{ mA} \times 5K$$
$$= 8.6 \text{ V}$$

∴ ∵ $V_C = 8.6V$, $V_B = 4.57V$
 $\Rightarrow Q$ in active mode

$$\therefore I_B = 0.0128 \text{ mA}$$

$$I_C = 1.28 \text{ mA}$$

$$I_E = 1.29 \text{ mA}$$

$$V_B = 4.57 \text{ V}$$

$$V_C = 8.6 \text{ V}$$

試題五：〈20分〉

Fig.3 shows the common-source amplifier. Draw ac small signal equivalent circuit (8%). Find voltage gain $A_v = v_o/v_i$ (4%), overall voltage gain $G_v = v_o/v_{sig}$ (4%), input resistance R_{in} (2%), and output resistance R_{out} (2%). (note: $r_o=0$)

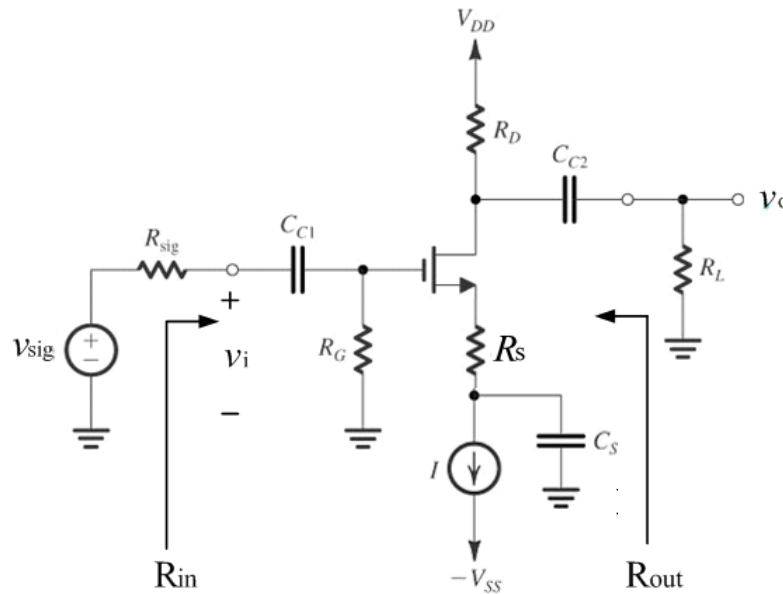
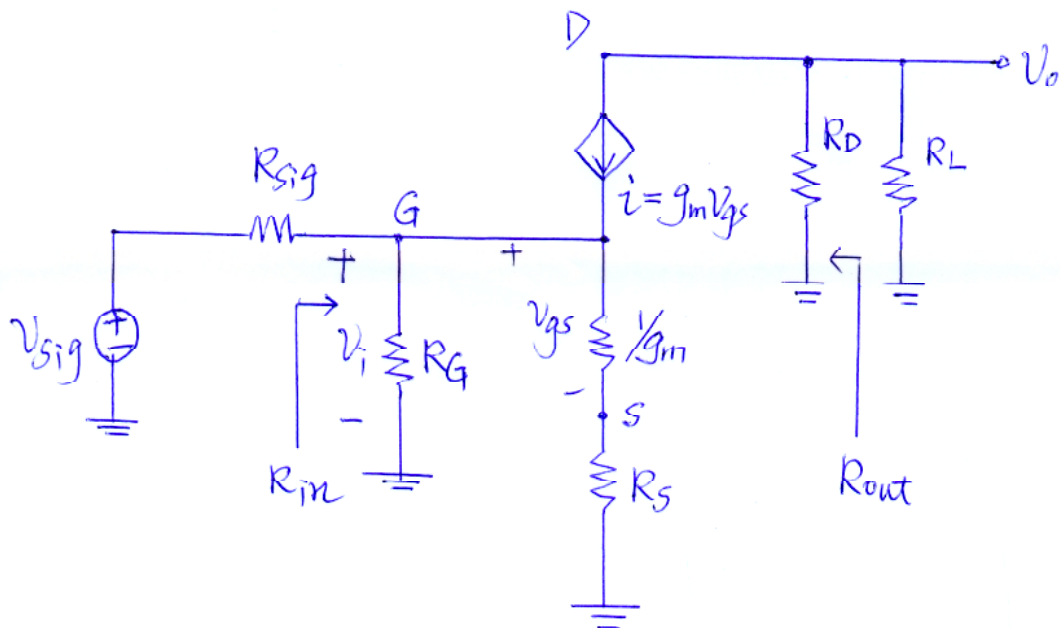


Fig. 3

Sol. = 1, ac small signal equivalent circuit =



$$2. A_v = \frac{V_o}{V_i}$$

$$\therefore V_o = -g_m V_{gs} (R_D \parallel R_L)$$

$$V_{gs} = \frac{1/g_m}{1/g_m + R_S} V_i = \frac{V_i}{1 + g_m R_S}$$

$$\Rightarrow V_i = (1 + g_m R_S) V_{gs}$$

$$\begin{aligned} \Rightarrow A_v &= \frac{-g_m V_{gs} (R_D \parallel R_L)}{(1 + g_m R_S) V_{gs}} \\ &= \frac{-g_m (R_D \parallel R_L)}{1 + g_m R_S} \end{aligned}$$

$$3. G_V = \frac{V_o}{V_{sig}} = \frac{V_i}{V_{sig}} \times \frac{V_o}{V_i} = - \left(\frac{R_G}{R_G + R_{sig}} \right) \frac{g_m (R_D \parallel R_L)}{1 + g_m R_S}$$

$$4. R_{in} = R_G$$

$$R_{out} = R_D$$

試題六：〈10分〉

A NMOS FET has $\mu_n C_{ox} = 100 \mu\text{A}/\text{V}^2$, $W/L = 40$, $V_t = 1\text{V}$, and $V_A = 10\text{V}$. Find g_m and r_o when $V_{GS} = 2\text{V}$.

$$I_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_t)^2 = \frac{1}{2} 100 \times 40 \times (2 - 1)^2 = 2000 \mu\text{A} = 2\text{mA}$$

$$g_m = \frac{2I_D}{V_{GS} - V_t} = \frac{2 \times 2\text{mA}}{1\text{V}} = 4\text{mA}/\text{V} \quad (5\%)$$

$$r_o = \frac{V_A}{I_D} = \frac{10\text{V}}{2\text{mA}} = 5\text{k}\Omega \quad (5\%)$$