國立中山大學100學年度碩士班招生考試試題

科目：電子學【光電所碩士班選考】

(第一部分) 單選題 35%

Figure 1 shows a circuit based on a MOSFET which works as an amplifier. Assume the channel-length modulation cannot be neglected, thus induces an output impedance r_o; please choose the correct answer of the following questions.

1. (5%) What is the input impedance (R_{in}) of the circuit?

(a) R_1 (b) $R_1 + R_S$ (c) $R_1 \| R_S$ (d) $R_1 \| R_D$ (e) ∞

2. (5%) What is the output impedance (R_{out}) of the circuit?

(a) R_D (b) r_O (c) $R_D + r_O$ (d) $R_D \| r_O$ (e) $R_D \| r_O \| R_S$

3. (5%) What is the voltage gain of the circuit?

(a) $g_m R_D$ (b) $-g_m R_D$ (c) $g_m(R_D \| r_O)$ (d) $-g_m(R_D \| r_O)$ (e) $-g_m(R_D \| r_O \| R_S)$

4. (5%) Which one is **unchanged** if C_S is removed?

(a) input impedance (b) output impedance (c) voltage gain (d) all of the above

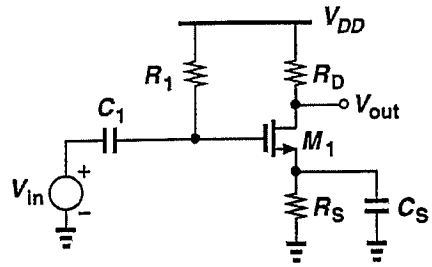

Figure 1

Figure 2 shows a circuit based on two BJT. Assume Early effect can be neglected, and the current gain of the two transistors Q_1 and Q_2 are β_1 and β_2, respectively.

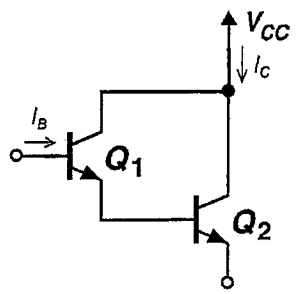

Figure 2

g_{m1} : transconductance of Q1

g_{m2} : transconductance of Q2

$r_{\pi 1}$: small-signal impedance of Q1 seen at the base

$r_{\pi 2}$: small-signal impedance of Q2 seen at the base

5. (5%) If the base of Q_1 is grounded, what is the impedance seen at the emitter of Q_2?

(a) $r_{\pi 1} + r_{\pi 2}$ (b) $r_{\pi 1} \| r_{\pi 2}$ (c) $(r_{\pi 1} \| \frac{1}{g_{m1}}) + r_{\pi 2}$ (d) $\frac{(r_{\pi 1} \| \frac{1}{g_{m1}}) + r_{\pi 2}}{\beta_2 + 1}$ (e) $\frac{(r_{\pi 1} \| \frac{1}{g_{m1}})}{\beta_2 + 1} + r_{\pi 2}$

6. (5%) If the emitter of Q_2 is grounded, what is the impedance seen at the base of Q_1?

(a) $r_{\pi 1} + r_{\pi 2}$ (b) $r_{\pi 1} \| r_{\pi 2}$ (c) $r_{\pi 1} + (\beta_1 + 1) r_{\pi 2}$ (d) $r_{\pi 1} + (\beta_2 + 1) r_{\pi 2}$ (e) $r_{\pi 1} \| (\beta_1 + 1) r_{\pi 2}$

7. (5%) what is the current gain I_C/I_B?

(a) $\beta_1 + \beta_2(1+\beta_1)$ (b) $\beta_1(1+\beta_2)$ (c) $\beta_1 + \beta_2$ (d) $\beta_1\beta_2$ (e) β_2/β_1

國立中山大學100學年度碩士班招生考試試題

科目：電子學【光電所碩士班選考】

(第二部分) 簡答題 **45%**, 題號請標註清楚

1. (5%) What are Zener breakdown and avalanche breakdown in pn junction?
2. (5%) Please define the drift current and diffusion current of semiconductors.
3. (5%) Draw the large-signal and small-signal model of a BJT operating in active region at low frequency.
4. (5%) A MOSFET can be viewed as a voltage-dependent resistor in triode region. Please draw the I_D-V_G characteristics and state the operational principles.
5. (5%) A MOSFET can be viewed as a voltage-controlled current source in saturation region. Please draw the I_D-V_G characteristics and state the operational principles.
6. (5%) Express the small signal transconductance g_m of a MOSFET operating in saturation region in terms of (a) I_D, V_{GS} and V_T and (b) I_D and W/L.
7. (5%) Please draw the physical structure of a PMOS and a NMOS including substrate, isolation island and contacts.
8. (5%) Please draw the circuit of a simple CMOS inverter and describe the operation principles.
9. (5%) What are the basic requirements on input impedance and output impedance for a "good" amplifier? Why?

(第三部分) 計算題 **20%**, 請寫出計算或推導過程

Figure 3 shows an op amp circuit.

1. (5%) Assume the op amp is ideal. Please derive the voltage gain V_{out}/V_{in} of the circuit and draw the equivalent circuit model.
2. (5%) If the op amp is not ideal and exhibits a finite open-loop gain A, please derive the voltage gain of the circuit.
3. (5%) In Figure 4, consider a capacitor C_1 is in parallel with R_2, please derive the expression for the transfer function $V_{out}(s)/V_{in}(s)$. Assume the op amp is ideal.
4. (5%) What is the dc gain and -3dB bandwidth of the circuit in Figure 4?

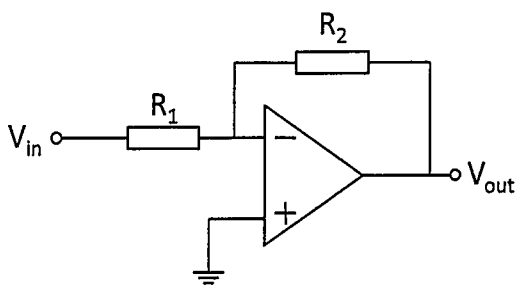

Figure 3

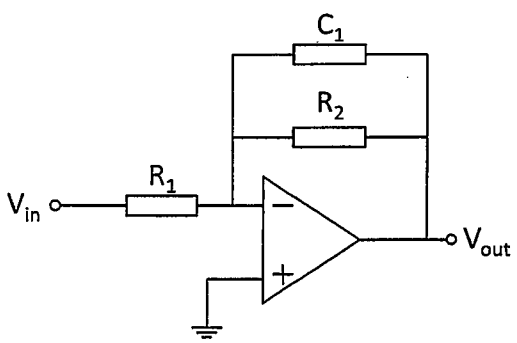

Figure 4