

# 國立臺北科技大學九十六學年度碩士班招生考試

系所組別：1901 光電工程系碩士班

## 第三節 電子學 (選考) 試題

第一頁 共二頁

### 注意事項：

1. 本試題共六題，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. (15%) Consider the circuit shown in Fig. 1.
  - (1) Express  $v_o$  as a function of  $v_1$  and  $v_2$ . (3%)
  - (2) What is the input resistance seen by  $v_1$  alone? (3%) By  $v_2$  alone? (3%)
  - (3) What is the input resistance by a source connected between the two input terminals? (3%)  
By a source connected to both input terminals simultaneously? (3%)
2. (15%) The CMOS inverter shown in Fig. 2 consists of a NMOS with  $k_n'(W/L)_n$  and a PMOS with  $k_p'(W/L)_p$ .
  - (1) Show that the threshold voltage  $V_{th}$  of a CMOS inverter is given by  

$$V_{th} = \frac{r \cdot (V_{DD} - |V_{tp}|) + V_{tn}}{1+r}$$
 where  $r = \sqrt{\frac{k_p'(W/L)_p}{k_n'(W/L)_n}}$  (5%)
  - (2) When  $V_{tn} = |V_{tp}| = V_t$  and  $k_n'(W/L)_n = k_p'(W/L)_p$ , derive the expressions for  $V_{IH}$  (minimum permitted logic-1 level at the input) and  $V_{IL}$  (maximum permitted logic-0 level at the input). (10%)

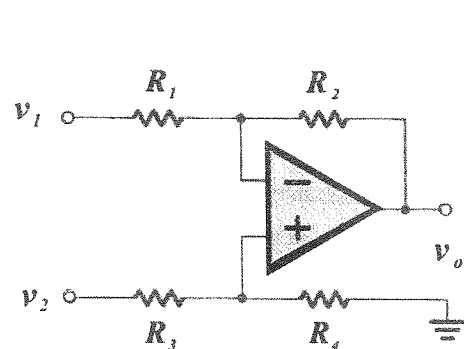


Fig. 1

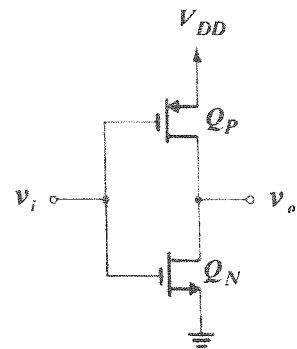


Fig. 2

3. (20%) For the common-emitter amplifier shown in Fig. 3, consider the effect of  $r_x$ .
  - (1) Find the following parameters:  $R_{in}$ ,  $R_{out}$ ,  $A_v$ , and  $G_v$ . (12%)
  - (2) Sketch the small-signal equivalent circuit and derive the expression for the upper 3-dB frequency  $f_H$ . (8%)

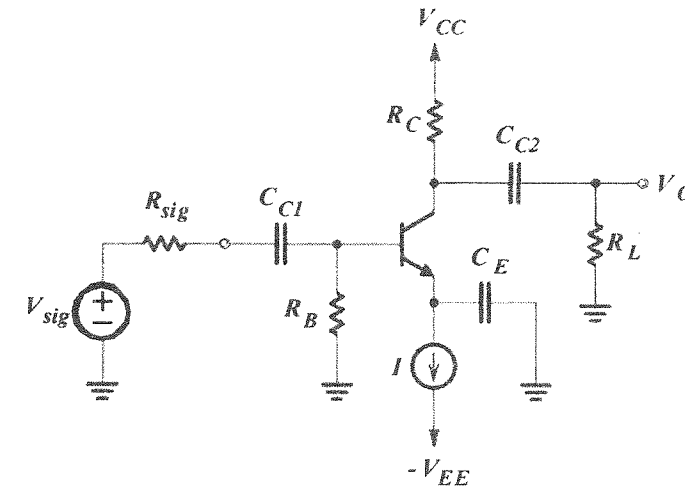


Fig. 3

4. (23%) Consider the BiCMOS amplifier shown in Fig. 4. The BJT has  $|V_{BE}| = 0.7V$ ,  $\beta = 240$ ,  $C_\mu = 1.55pF$ , and  $f_T = 800MHz$ . The NMOS transistor has  $V_t = 1V$ ,  $k_n'(W/L)_n = 4mA/V^2$ .
  - (1) Neglect the base current of  $Q_2$ , find the dc bias currents in  $Q_1$  and  $Q_2$ . (4%)
  - (2) Evaluate the small-signal parameters  $g_{m1}$ ,  $g_{m2}$ ,  $r_{\pi 2}$ ,  $C_{\pi 2}$ . (8%)
  - (3) Neglect the effect of  $R_G$ , determine the small-signal voltage gain  $V_o/V_i$  at the midband frequencies. (5%)
  - (4) Determine the amplifier input resistance  $R_{in}$  (3%) and the overall voltage gain  $V_o/V_{sig}$  (3%).

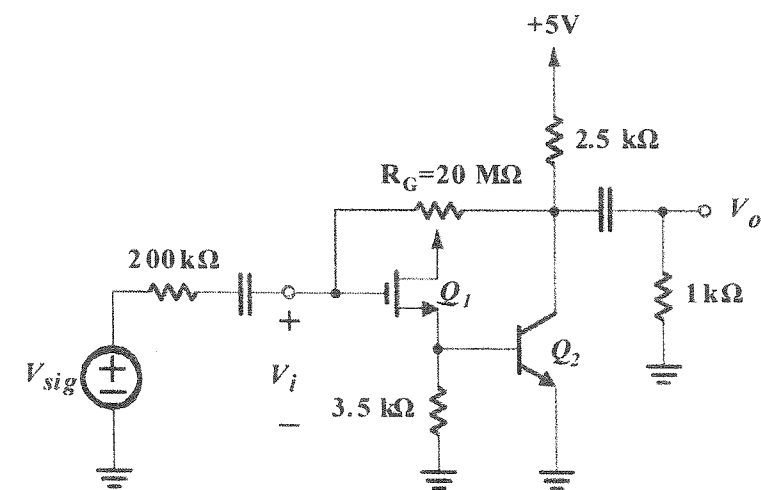


Fig. 4

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5. (15%) The equivalent circuit of a two-stage CMOS op amp is shown in Fig. 5. Find the amplifier transfer function  $V_o/V_{id}$  (9%) and two pole frequencies when one of them is dominant. (6%).

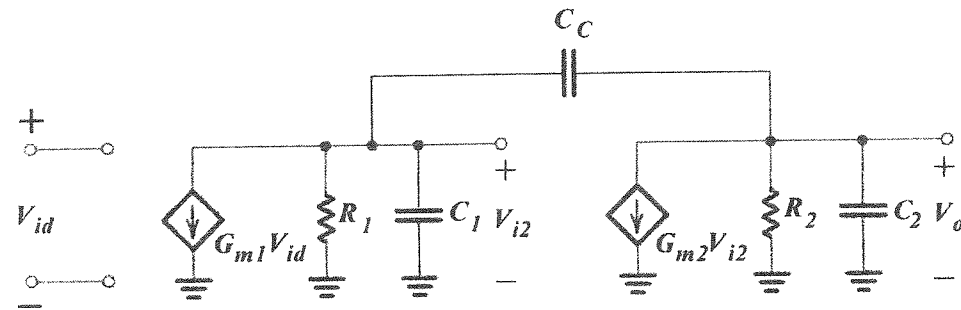


Fig. 5

6. (12%) For the series-series feedback amplifier in Fig. 6, the op amp is characterized by an open-loop voltage gain  $\mu=10^5$  V/V, an input differential resistance  $R_{id}=20$  k $\Omega$ , and an output resistance  $r_o=200$   $\Omega$ . The amplifier supplies a current  $i_o$  to a load resistance  $R_L=2$  k $\Omega$ . Find the gain-with-feedback  $A_f \equiv i_o/v_s$  (6%), the input resistance  $R_m$  (3%), and the output resistance  $R_{out}$  (3%).

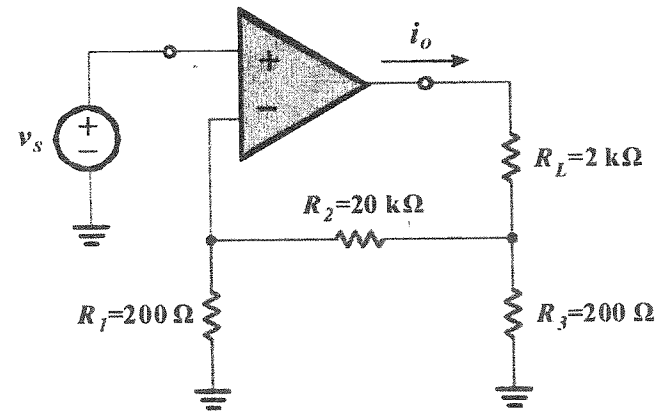


Fig. 6