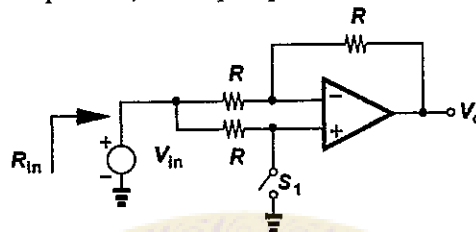


※ 注意：請於試卷上「非選擇題作答區」內依序作答，並應註明作答之大題及其題號。

共四大題

Problem 1: (30 pts, 3 pts each, 填充, 中英皆可)

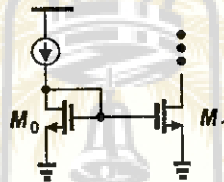
(a) For the following op amp circuit, if the op amp is ideal



(1) When switch  $S_1$  is ON, what is the close-loop gain  $(V_o/V_{in}) = ( \text{①} )$  and  $R_{in} = ( \text{②} )$ ?

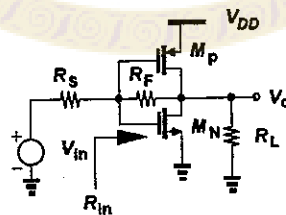
(2) When switch  $S_1$  is OFF, what is the close-loop gain  $(V_o/V_{in}) = ( \text{③} )$  and  $R_{in} = ( \text{④} )$ ?

(b) For a CMOS current mirror as follows, what are TWO factors to induce the current mismatch between  $M_1$  and  $M_0$ ? The nominal size for  $M_1$  and  $M_0$  are the same.



(  $\text{⑤}$  ) and (  $\text{⑥}$  )

(c) For the following circuits, please neglect channel length modulation and derive the following parameters by  $g_{mp}$ ,  $g_{mn}$ ,  $R_F$  and  $R_L$ . Note that  $g_{mp}$  and  $g_{mn}$  are the transconductance for  $M_P$  and  $M_N$ , respectively.



(1)  $R_{in} = ( \text{⑦} )$

(2) close-loop gain  $(V_o/V_{in}) = ( \text{⑧} )$

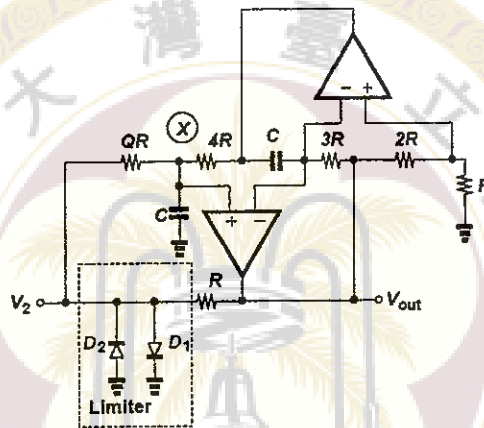
(d) For a real op amp, it has the following nonideal effect, (I) finite open-loop gain, (II) finite output impedance, (III) finite max/min output swing, (IV) finite slew rate and (V) finite small-signal bandwidth. Please use (I), (II) and so on for the answers.

見背面

- (1) Which ones can induce linear error (no harmonic distortion at the output)?  
 (      ⑨      )
- (2) Which ones can induce non-linear error (with harmonic distortion at the output)?  
 (      ⑩      )

Problem 2~4 計算題，請寫過程

2. (28pts) The active-filter tuned oscillator is shown as below. If  $C$  is equal to 1 nF and  $R$  is equal to 1.6 K $\Omega$ . Note that  $Q$  is quite large.



- (a) (5 pts) What is the oscillation frequency?
- (b) (6pts) If the turn-on voltage of the diode is 1V, what is the peak-to-peak amplitude at node  $X$ ? No score will be given without derivation. Is it a sine wave or square wave? (Hint: A square wave with peak-to-peak amplitude of  $V$  volts has a fundamental component with  $4V/\pi$  volts peak-to-peak amplitude).
- (c) (5 pts) If we move the limiter to node  $X$ , what is the peak-to-peak amplitude at the output  $V_{out}$ ?
- (d) (12 pts) Now, the op amp has parasitic input capacitance 0.1 nF at both positive and negative input nodes. Please repeat part (a)

3. (25 pts) For the following circuit in Fig. 3-1, neglect body effect in all transistors. Note that  $(W/L)_{1,2}=40/1$ ,  $(W/L)_{3,4}=100/1$ ,  $\mu_n C_{ox}=50 \mu A/V^2$ ,  $\mu_p C_{ox}=20 \mu A/V^2$ ,  $V_{An}=100 V$ ,  $|V_{Ap}|=66.67 V$ ,  $V_{tn}=0.5 V$ , and  $V_{tp}=-0.5 V$ .

接次頁

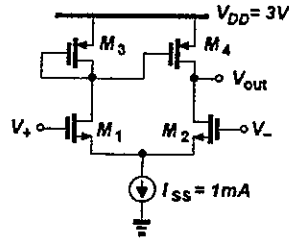


Fig. 3-1

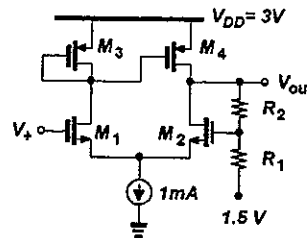


Fig. 3-2

- (a) (10 pts) First, let's set  $V_+ = 1.5 \text{ V} + 0.001 \sin(\omega t)$  and  $V_- = 1.5 \text{ V}$ . What is  $V_{out}$ ? Please include both DC and AC.
- (b) (15 pts) Now, a resistive feedback network is included as shown in Fig. 3-2, where  $R_2=100 \text{ K}\Omega$  and  $R_1=10 \text{ K}\Omega$ . What is  $V_{out}$  if  $V_+ = 1.5 \text{ V} + 0.001 \sin(\omega t)$ ?
4. (17 pts) In this problem, we want to study CMOS logic gate design,

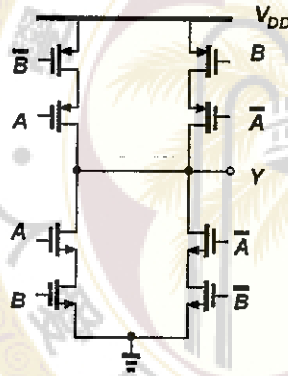


Fig. 4-1

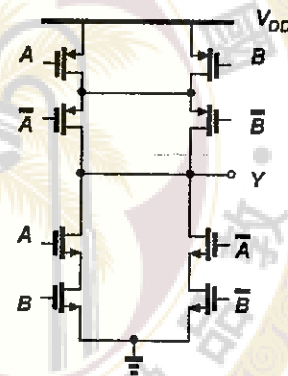


Fig. 4-2

- (a) (7 pts) Shown in the following Fig. 4-1 and Fig. 4-2, explain why these two designs can generate identical logic function? What is Boolean function? Which topology would you prefer in practical design? Explain why you choose such topology. Note that  $A, \bar{A}, B,$  and  $\bar{B}$  are the logic inputs and  $Y$  is the output.

Now, use Fig Fig. 4-1 for the following questions,

- (b) (4 pts) Choose proper PMOS/NMOS size ratio to obtain identical worst-case the propagation delay of high to low ( $T_{phl}$ ) and low to high ( $T_{plh}$ ). Please identify the worst-case H->L and L->H condition.
- (c) (6 pts) By using the size in (b), if we choose  $V_{dd}=3\text{V}$  and  $V_{in}=|V_{tp}|=0.5\text{V}$ , what is the switching threshold voltage  $V_m$ ? Note that  $V_m$  is defined as an input voltage,  $V_{in}$ , would generate an output voltage that is the same as the input voltage. Note that  $V_B=3\text{V}$  and  $V_A=V_{in}$ . Body effect should be neglected for simplicity.

試題隨卷繳回