

科目：電子學

適用：電機系

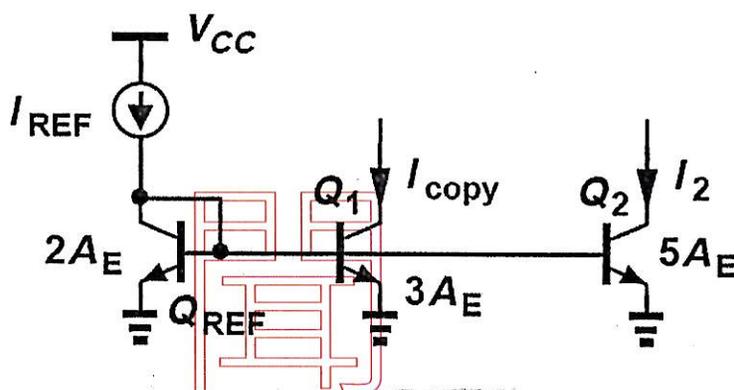
考生注意：

1. 依次序作答，只要標明題號，不必抄題。
2. 答案必須寫在答案卷上，否則不予計分。
3. 限用藍、黑色筆作答；試題須隨卷繳回。

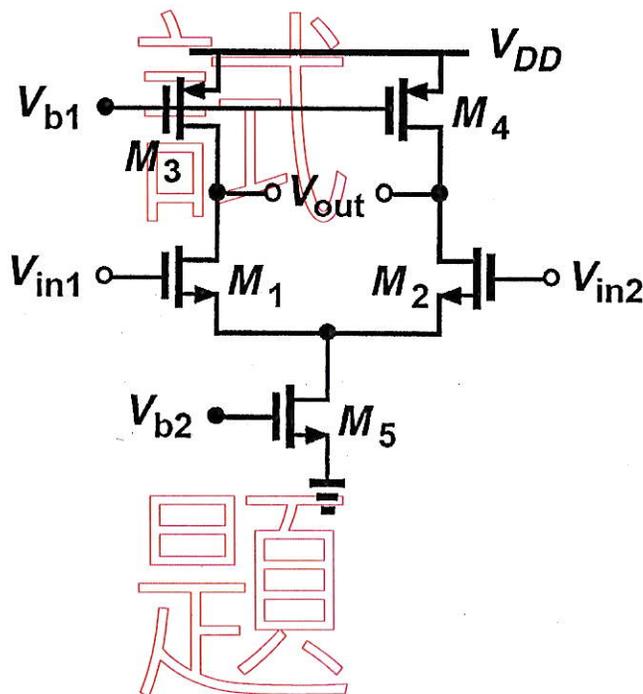
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1. A PN junction has the following doping levels:  $N_A = 5 \times 10^{16} \text{ cm}^{-3}$  and  $N_D = 2 \times 10^{17} \text{ cm}^{-3}$ , where  $N_A$  and  $N_D$  are the acceptor and donor density, respectively. Assume the intrinsic density  $n_i = 10^{10} \text{ cm}^{-3}$ .
  - (a) Determine the electron and hole densities in both side of the PN junction. [5%]
  - (b) Determine the junction's built-in potential ( $V_0$ ). Use  $V_T = 25 \text{ mV}$  and  $\ln(10) \approx 2.3$  [5%]
  
2. All transistors shown in the current mirror below have the same value of  $\beta$ , and  $A_E$  is the emitter area of the transistor.
  - (a) If base current is neglected and  $I_{REF}$  is equal to 2mA, determine the value of  $I_{copy}$ . [5%]
  - (b) Taking base currents into account, derive  $I_{copy}$  in terms of  $I_{REF}$ . [5%]



3. Assuming the same (equilibrium) overdrive voltage for all of the MOS transistors and a power dissipation of 2 mW, design the differential pair shown below to provide a gain of 48. What are the (W/L) sizes of all the MOS? Assume  $\lambda_n = (1/8) \text{ V}^{-1}$ ,  $\lambda_p = (1/12) \text{ V}^{-1}$ ,  $\mu_n C_{ox} = 100 \mu\text{A/V}^2$ ,  $\mu_p C_{ox} = 50 \mu\text{A/V}^2$ , and  $V_{DD} = 2 \text{ V}$ . [15%]



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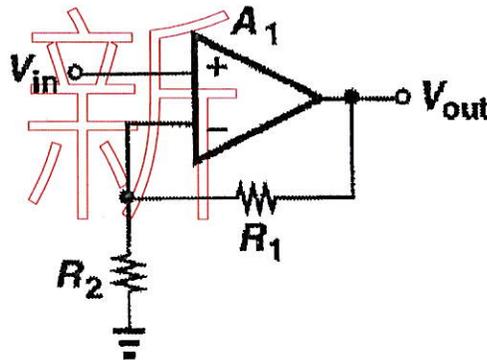
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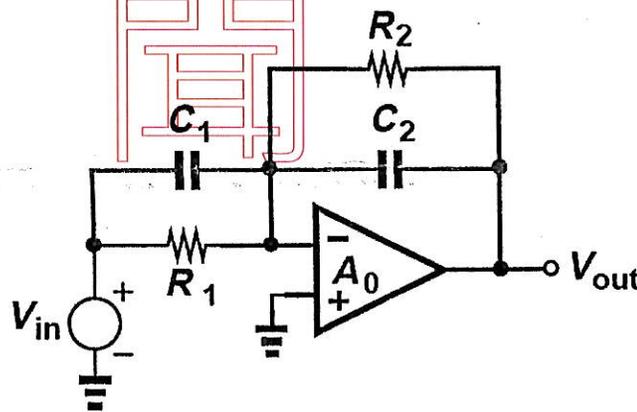
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4. A non-inverting amplifier is shown below.

- (a) If the op-amp is ideal, find the voltage gain of the amplifier ( $A_v = V_{out}/V_{in}$ ). [5%]
- (b) If the op-amp is not ideal with open-loop gain of  $A_1$  and the amplifier is designed for a nominal voltage gain of 10, determine the required minimum value of  $A_1$  for a gain error of 1%. Assume  $(1+x)^{-1} \approx 1-x$ . [5%]

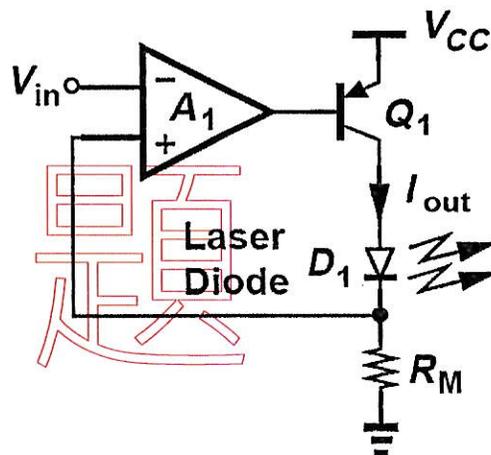


5. (a) Calculate the transfer function,  $H(s) = V_{out}(s)/V_{in}(s)$  of the circuit if  $A_0 = \infty$ . [10%]
- (b) What choice of component values reduces  $|V_{out}/V_{in}|$  to unity at all frequencies? [5%]



6. The circuit shown below can deliver a well-defined current to laser diode,  $D_1$ , where resistor  $R_M$  measures the current flowing through  $D_1$  and amplifier  $A_1$  subtracts the resulting voltage drop from  $V_{in}$ . Assume  $R_M$  is very small and amplifier  $A_1$  is ideal.

- (a) Determine the open-loop gain, loop gain and the closed-loop gain. [10%]
- (b) Compute the open-loop and closed-loop output impedances. [5%]



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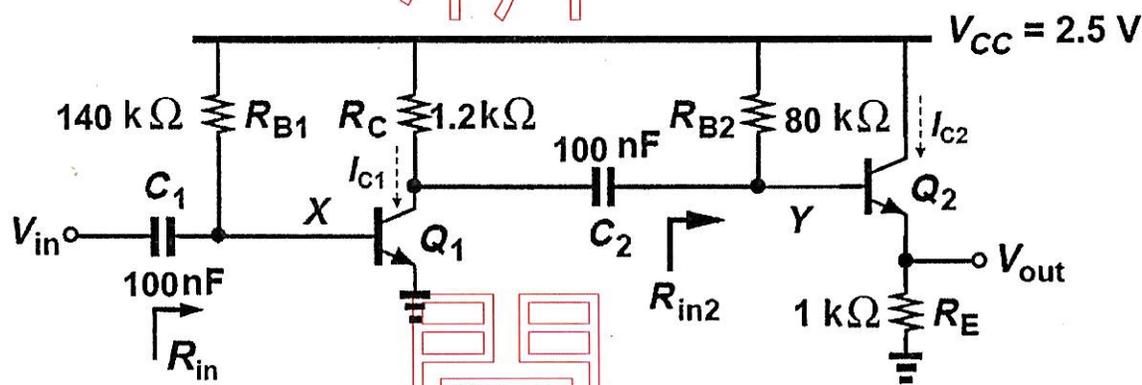
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7. The two-stage amplifier shown below incorporates capacitive coupling both at the input and between the stages. Assume the transistors have  $\beta = 100$  and  $V_A = \infty$ . Also, the bias current of the two transistors are  $I_{C1} = 1.25 \text{ mA}$  and  $I_{C2} = 1 \text{ mA}$ , respectively.
- (a) Assume the two capacitors are large enough for the frequency interested. Use hybrid- $\pi$  model to draw the small signal equivalent model of the amplifier. Use  $V_T = 25 \text{ mV}$  for the calculation of small signal parameters. [5%]
- (b) Following (a), determine the voltage gain of the amplifier. [5%]
- (c) Determine the low-frequency cut-off of the circuit. [5%]



8. All the diodes in the circuit are ideal. *A*, *B*, *C* are logic input, and *OUT* is logic output. The logic 0 voltage is within 0~1V and the logic 1 is 4~5V.
- (a) Assume  $R_1 = 5 \cdot R_2$ , what is the logic function of *OUT*? [5%]
- (b) What problem would happen if  $R_1 = R_2$ ? [5%]

