

科目：電子學一(元件)

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。

本 試 題

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第 1 頁

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1. A PN junction is doped with boron (B) of  $N_A = 5 \times 10^{16} \text{ cm}^{-3}$  and with phosphorous (P) of  $N_D = 2 \times 10^{17} \text{ cm}^{-3}$  on P and N sides, respectively. Use  $n_i = 1.0 \times 10^{10} \text{ cm}^{-3}$ , and  $V_T = 25 \text{ mV}$ .
  - (a) Determine the majority and minority carrier concentrations on P and N sides. [5%]
  - (b) Determine the built-in barrier potential. (Use  $\ln 10 = 2.3$ ) [5%]

2. In Fig. 1, assume the diode has a constant-voltage model with  $V_{D,ON} = 0.8 \text{ V}$ .

- (a) If  $V_S$  is 10V, calculate node voltage  $V_X$  and the diode current  $I_D$ . [5%]
- (b) Determine the value of  $V_S$  such that the diode is turned off (i.e.  $I_D = 0$ ). [5%]

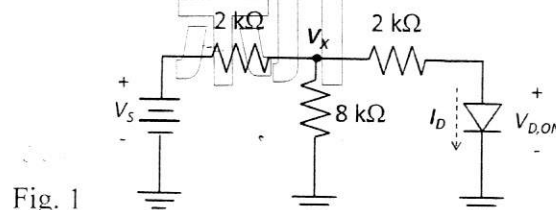


Fig. 1

3. In Fig. 2, assume the diode has a constant-voltage model with  $V_{D,ON} = 0.8 \text{ V}$ , plot the input/output characteristic for the following circuit. [10%]

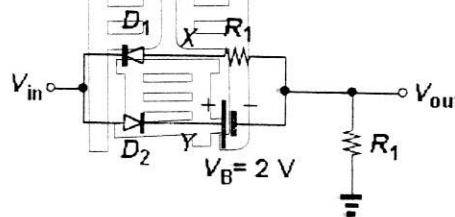


Fig. 2

4. In the circuit of Fig. 3,  $Q_1$  and  $Q_2$  are identical, and have their  $V_{BE}$  and  $I_C$  relation as listed in the following Table, and  $I_{S1} = I_{S2} = 1.5 \times 10^{-16} \text{ A}$ .

| $V_{BE} \text{ (V)}$ | 0.70 | 0.71 | 0.72 | 0.73 | 0.74 | 0.75 | 0.76 | 0.77 | 0.78 | 0.79 | 0.80 |
|----------------------|------|------|------|------|------|------|------|------|------|------|------|
| $I_C \text{ (mA)}$   | 0.15 | 0.22 | 0.31 | 0.47 | 0.70 | 1.00 | 1.50 | 2.20 | 3.22 | 4.71 | 6.92 |

- (a) For what value of  $V_B$  to make  $I_X = 3.0 \text{ mA}$ ? [5%]
- (b) With the value of  $V_B$  found in part (a), what is  $I_{S3}$  of  $Q_3$  to make  $I_Y = 5.0 \text{ mA}$ . [5%]
- (c) Using the current in part (b) find the small signal parameters of  $Q_3$ , i.e. calculate  $g_{m3}$ ,  $r_{\pi 3}$ , and  $r_{O3}$  if  $\beta = 100$ ,  $V_A = 30 \text{ V}$ , and  $V_T = 25 \text{ mV}$ . [5%]

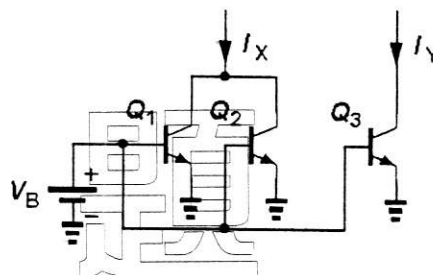


Fig. 3

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5. For the MOSFET  $M_1$  shown in Fig. 4 is biased at four different cases. Assume the threshold voltage,  $V_{T1}$ , of  $M_1$  is 0.5V. What is its operation mode for each case? Answer each with *cutoff*, *linear*, or *saturation*. [10%]

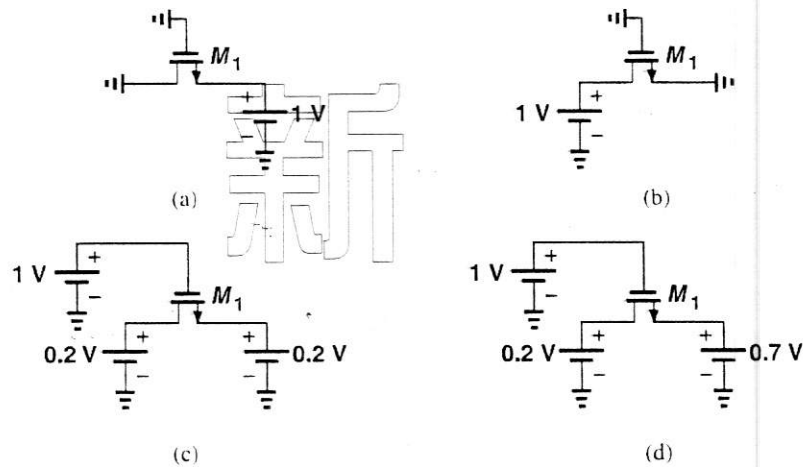


Fig. 4

6. For the circuit in Fig. 5, determine  $V_{GS}$ ,  $I_D$ , and  $g_m$  of  $M_1$ .  
Use  $\mu_n C_{ox} = 200 \mu\text{A}/\text{V}^2$ ,  $V_{TH} = 0.5 \text{ V}$ ,  $\lambda = 0$ . [10%]

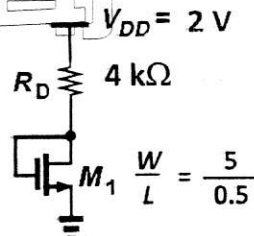


Fig. 5

7. Please briefly explain the following terms or questions.

- (a) Drift and Diffusion currents in semiconductor [5%]
- (b) Depletion region of a diode. [5%]
- (c) Early effect in BJT [5%]
- (d) Body effect in MOSFET [5%]
- (e) Why CMOS displacing BJT [5%]

8. Complete the English for the following acronym. [10%]

- (a) BJT = B \_\_\_\_\_ J \_\_\_\_\_ T \_\_\_\_\_
- (b) CMOS = C \_\_\_\_\_ M \_\_\_\_\_ O \_\_\_\_\_ S \_\_\_\_\_
- (c) LED = L \_\_\_\_\_ E \_\_\_\_\_ D \_\_\_\_\_