

1. In the differential amplifier circuit as shown, all transistors are matched with parameters  $\beta=100$ ,  $V_A=100$  V,  $V_{BE(on)}=0.7$  V,  $V_{CE,sat}=0.3$  V.

(1) Calculate the following parameters: (10%)

- $g_m$  value of  $Q_1$  and  $Q_2$
- differential voltage gain  $V_o/(V_1-V_2)$
- differential input resistance

(2) Find the minimum input common mode voltage  $V_{CM,min}$  and the output voltage swing  $V_{o,min}$ , and  $V_{o,max}$ . (9%)

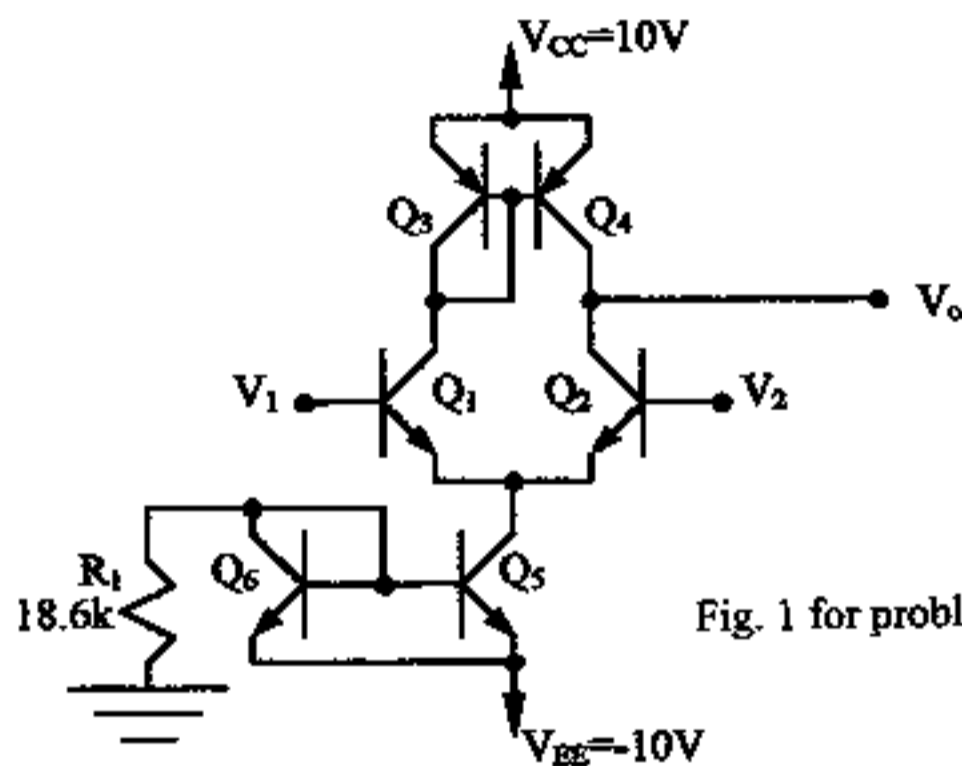


Fig. 1 for problem 1.

2. A common emitter amplifier was found to have a single-time-constant high frequency response with mid-band voltage gain of 40 dB and upper 3-dB frequency of 100 KHZ.

(1) Sketch the Bode plot for the voltage gain  $|A|$  (3%)

(2) Find  $|A|_{dB}$  for frequencies at 400 KHZ and 4 MHz. (5%)

3. In the circuit, the op-amp is ideal and the BJT has  $\beta=\infty$ .

(1) What is the feedback topology?

Explain your reason.

(2) Find the voltage gain  $V_o/V_s$ .

(3) Find the power dissipation on the BJT when  $V_s=2$  V.

(8%)

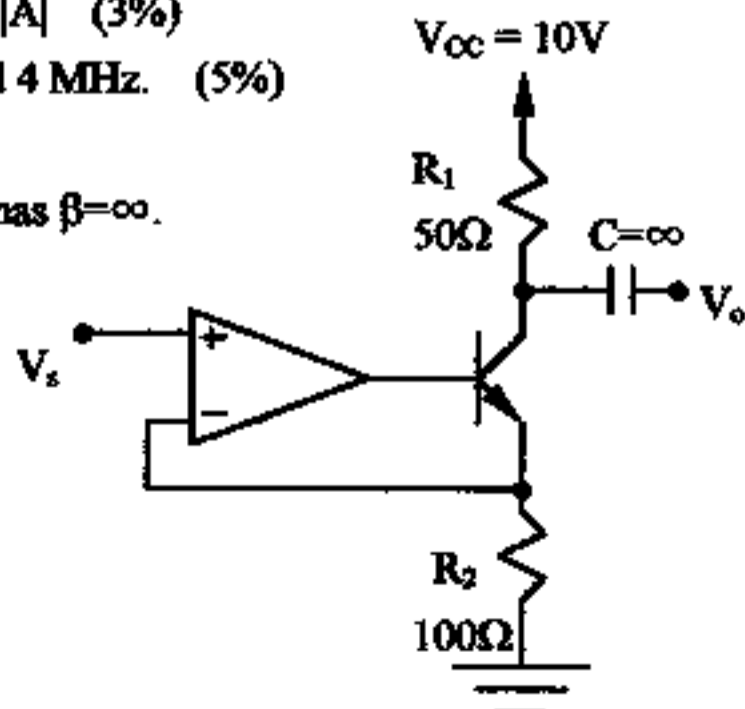


Fig. 2 for problem 3.

科目：電子學 科號：4102/3802 共 3 頁第 2 頁 \*請在試卷【答案卷】內作答

4. A lightly doped pn diode is used for light detector with  $N_a=2 \times 10^{14} \text{ cm}^{-3}$  and  $N_d=1 \times 10^{16} \text{ cm}^{-3}$ . Assume the depletion region widths in the p region and the n region are  $W_p$  and  $W_n$ , respectively.
- What is  $W_p/W_n$ ? (5%)
  - Find the maximum  $W_p$  and  $W_n$  that can be obtained if the junction breaks down at reverse bias voltage of 30V and assume the critical field for junction breakdown is  $1 \times 10^6 \text{ V/cm}$ . (5%)
5. For a common-source stage with a resistor load is shown in Fig. 3 below. Assume  $k_p=100 \mu\text{A/V}^2$ ,  $W=20 \mu\text{m}$ ,  $L=1 \mu\text{m}$ ,  $V_T=1\text{V}$  and neglect channel length modulation effect for M1.
- Find the input bias range within which M1 is in saturation. (5%)
  - What is the maximum small-signal voltage gain of this circuit? (5%)
  - Propose changes in the circuit parameters so the input bias range can be increased. (5%)
  - Replace M1 with a BJT, Q1 with  $I_s=1 \times 10^{-15} \text{ A}$  (neglect base current). Estimate the input bias range within which Q1 is in forward-active region. (5%) (FYI:  $\ln 2=0.69$ ,  $\ln 3=1.1$ ,  $\ln 5=1.6$ ,  $\ln 7=1.9$ ,  $\ln 10=2.3$ )

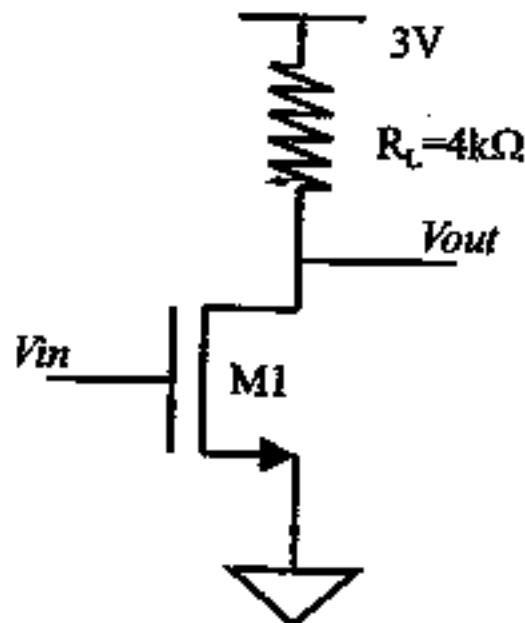


Fig.3 for problem 5.

6. For Fig. 4 below,

- (a) Draw the Input-output plot with explanations. 5%  
 (b) What is this circuit's name? 5%  
 (c) What are the limitations/constraints of this circuit? 5%

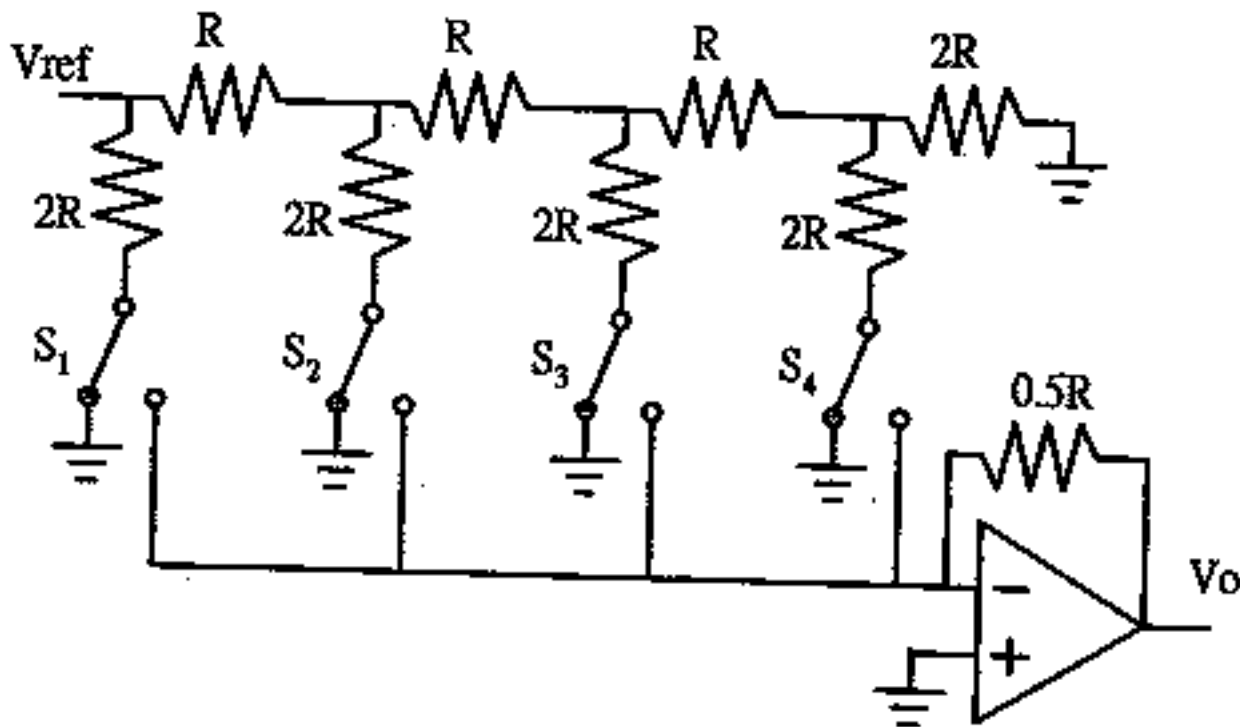


Fig. 4 for problem 6.

7. In Fig. 5, the saturated outputs for the ideal Op Amp are +10V and -10V,  
 (a) If  $V_{ref} = 0V$ , draw the  $V_i$ - $V_o$  plot with explanations. (5%)  
 (b) If  $V_{ref} = 5V$ , draw the  $V_i$ - $V_o$  plot with explanations. (5%)  
 (c) How do you get precise output level by using a resistor and two Zener diodes? 5%  
 (d) Also draw the  $V_i$ - $V_o$  plot in (c) and show the values of the output levels with  $V_{Z,reverse} = 5V$  and  $V_{Z,forward} = 0.5V$  (5%)

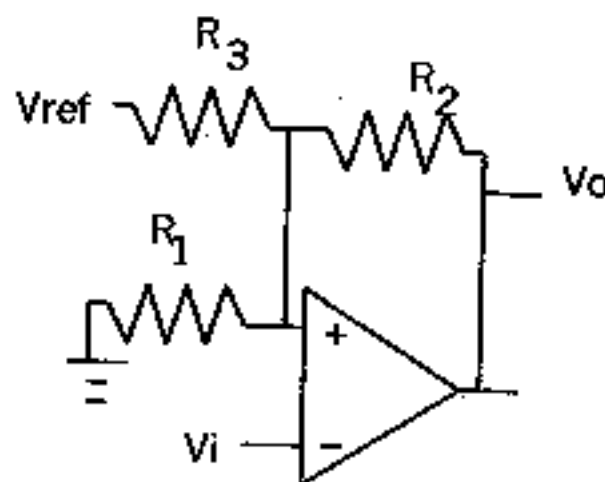


Fig. 5 for problem 7