

1. (a) Please define the electron mobility. (5%)
 (b) Based on the concept of energy band, define the insulator, intrinsic semiconductor, extrinsic semiconductor, and metal briefly. (5%)
 (c) What is the difference between drift current and diffusion current? (5%)
2. For the circuit shown in Fig. 2(a), $R_1 = 2k\Omega$, $R_2 = 3k\Omega$, and $R_3 = 950\Omega$. Also, the piecewise-linear model, Fig. 2(b), is used with $V_{D0} = 0.8V$, $r_D = 50\Omega$. If V_{BB} is changed from $-4V$ to $+5V$, calculate the change of V_o , i.e. $V_o(V_{BB} = +5V) - V_o(V_{BB} = -4V)$. (10%)

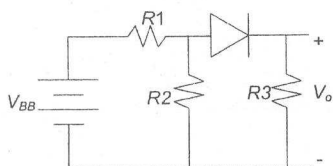


Fig. 2(a)

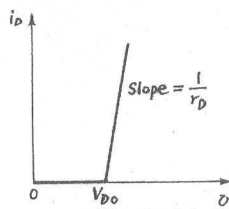


Fig. 2(b)

3. A CMOS amplifier is shown in Fig. 3. Assume each transistor has the same process parameter $K = 0.5 \cdot \mu C_{ox}(W/L)$, threshold voltage $|V_T|$, and intrinsic resistor r_o .
 (a) Find the ratio R_1/R_2 to bias the circuit at linear region of the transfer curve. (3%)
 (b) Sketch the small-signal equivalent circuit, and find v_o/v_i and R_{out} . (10%)

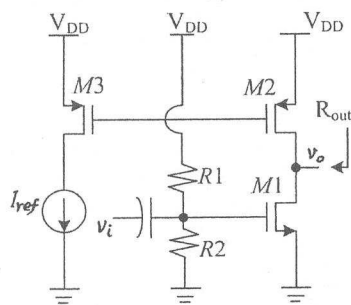


Fig. 3

4. As shown in Fig. 4, find the relationship between I_3 and I_1 in terms of K_1 , K_2 , K_3 , and K_4 of the four transistors. Note that K denotes $0.5 \cdot \mu C_{ox}(W/L)$. Assume the threshold voltages of all transistors are equal in magnitude. In the case that $K_1 = K_2$ and $K_3 = K_4 = 4K_1$, find the required value of I_1 to yield a bias current in M_3 and M_4 of 6.4 mA . (12%)

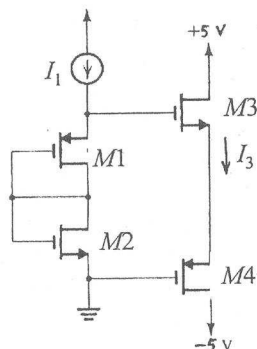
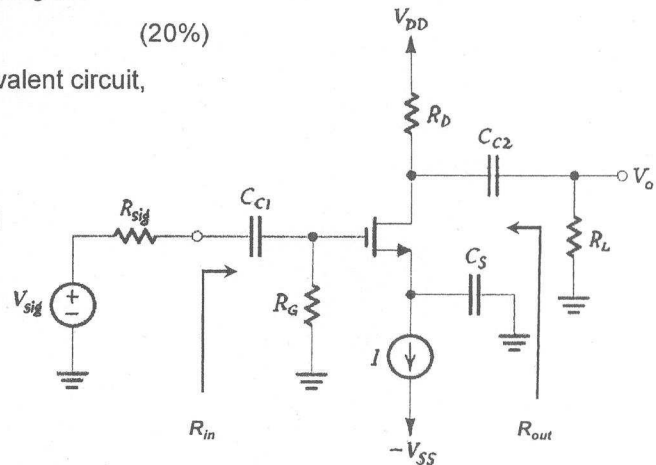


Fig. 4

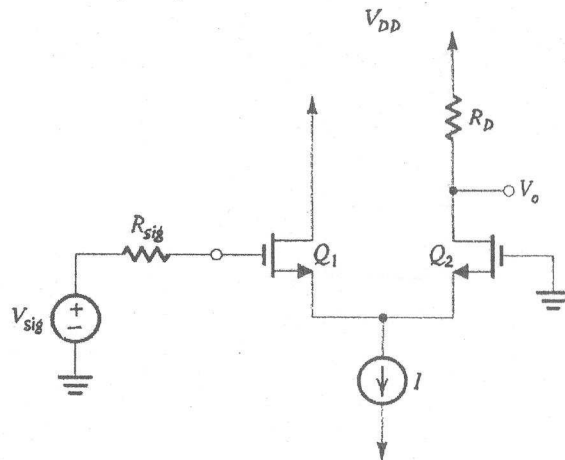
5. For the NMOS amplifier shown, assuming the three capacitors are very large, (20%)

- (a) draw the complete small signal equivalent circuit,
- (b) specify the input resistance R_{in} ,
- (c) specify the output resistance R_{out} ,
- (d) derive the voltage gains v_o/v_{sig} , and
- (e) derive the high 3-dB frequency f_H .



6. For the circuit shown: $I=200 \mu A$, $V_{OV}=0.25 V$, $R_{sig}=200 k\Omega$, $R_D=50 k\Omega$, $C_{gs}=C_{gd}=1 pF$, calculate (15%)

- (a) the dc gain,
- (b) the high-frequency poles, and
- (c) an estimate of f_H .



7. For the feedback amplifier, neglect r_o and the body effect. (15%)

- (a) Please specify what kind of feedback it is. (3%)
- (b) Derive A . (4%)
- (c) derive β , and (4%)
- (d) derive A_f . (4%)

