EE303 - Problem Set

Problem 1

Consider the differential pair illustrated in Fig. 10.70. Assuming perfect symmetry and $V_A = \infty$,

(a) Determine the voltage gain.

(b) Under what condition does the gain become *independent* of the tail currents? This is an example of a very linear circuit because the gain does not vary with the input or output signal levels.

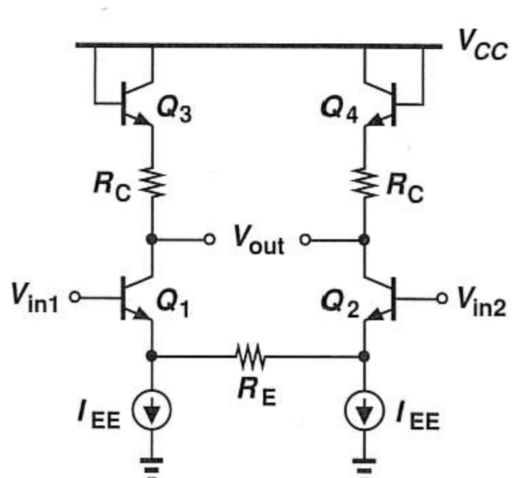

Figure 10.70

Problem 2

Consider the MOS differential pair of Fig. 10.24. What happens to the tail node voltage if (a) the width of M_1 and M_2 is doubled, (b) I_{SS} is doubled, (c) the gate oxide thickness is doubled?

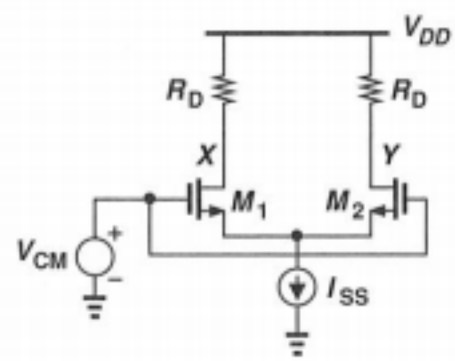

Figure 10.24 Response of MOS differential pair to input CM variation.

Problem 3

Calculate the differential voltage gain of the circuits depicted in Fig. 10.76. Assume perfect symmetry and $\lambda > 0$.

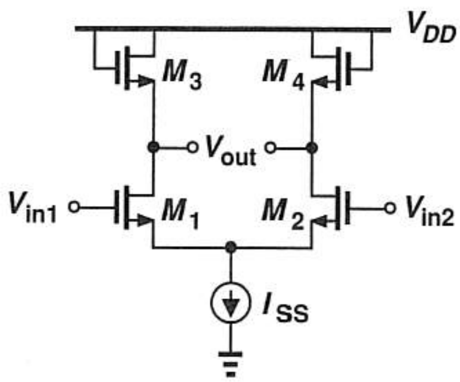

Fig. 10.76 (a)

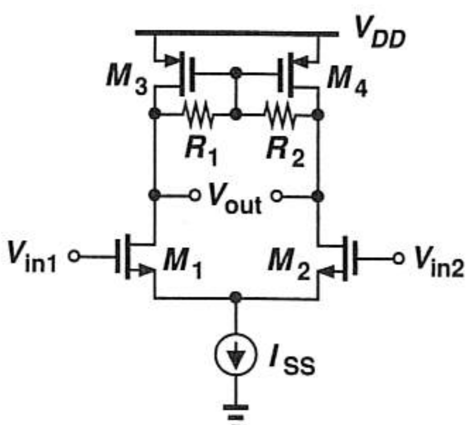

Fig. 10.76 (b)

Problem 4

Design an nMOST differential pair with the following parameters:
I_{TAIL} = 0.4 mA, V_{TH}=0.5V, $\mu C_{ox}(W/L)$ = 4mA/V^2, V_{DD}=1.5V, V_{SS}=–1.5V, R_D=2.5KΩ
Neglect channel length modulation:

Analytically:

a. Find V_{OV} and V_{GS} at equilibrium
b. For V_{CM}=0 find the values of V_S, I_{D1}, I_{D2}, V_{D1}, V_{D2}
c. Repeat (b) for V_{CM}=1V
d. Repeat (b) for V_{CM} = 0.2V
e. What is the highest value of V_{CM} for which M_1 and M_2 remain in saturation?
f. If the current source I_{TAIL} requires a minimum voltage of 0.4V to operate properly, what is the lowest value allowed for V_{CM}?
g. What is the range of differential mode operation (i.e. the range of $V_{id}=V_{in1}-V_{in2}$ for which M_1 and M_2 are "ON")
h. Assuming the output differential pair is taken single-ended, plot the differential voltage amplification $A_{Vd}=v_{out1}/v_{id}$ and the common mode voltage amplification $A_{Vc} = v_{oc}/v_{ic}$.