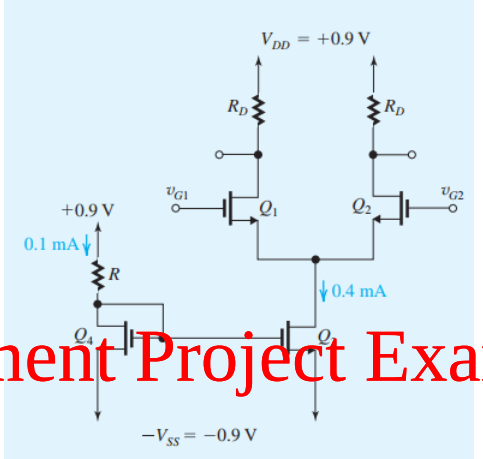
6.1 Design the circuit in Fig. 1 to obtain a dc voltage of +0.1v at each of the drains of Q1 and Q2 when $v_{G1} = v_{G2} = 0v$. Operate all transistors at V_{ov}= 0.15v and assume that for the process technology in which the circuit is fabricated, V_{in}=0.4v and $\mu_n C_{ox} = 400\ \mu A/V^2$. Neglect channel-length modulation. Determine the values of R, R_D, and W/L ratios of Q_1, Q_2, Q_3, and Q_4. What is the input common-mode voltage range for your design?

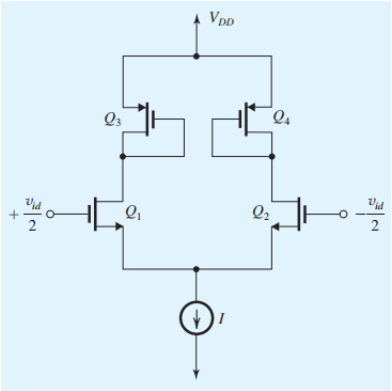


6.2 Figure 2 shows a MOS differential amplifier with the drain resistors R_D implemented using diode-connected PMOS transistors, Q_3 and Q_4. Let Q_1 and Q_2 be matched, and Q_3 and Q_4 be matched.

(a) Find the differential half-circuit and use it to derive an expression for A_d in terms of $g_{m1,2}$, $g_{m3,4}$, $r_{o1,2}$, and $r_{o3,4}$.

(b) Neglecting the effect of the output resistances r_o, find A_d in terms of μ_n, μ_p, $(\frac{W}{L})_{1,2}$, $(\frac{W}{L})_{3,4}$.

(c) if μ_n=4 μ_p and all four transistors have the same channel length, find ($W_{1,2}/W_{3,4}$) that results in A_d=10 V/V.



6.3 Figure 3 shows a circuit for a differential amplifier with an active load. Here Q_1 and Q_2 form the differential pair, while the current source transistors Q_4 and Q_5 form the active loads for Q_1 and Q_2, respectively. The dc bias circuit that establishes an appropriate dc voltage at the drains of Q_1 and Q_2 is not shown. It is required to design the circuit to meet the following specifications:

(a) Differential gain A_d = 50 V/V.

(b) I_{REF}=I=200 μA

(c) The dc voltage at the gates of Q_6 and Q_3 is +0.8V.

(d) The dc voltage at the gates of Q_7, Q_4, and Q_5 is −0.8V.

The technology available is specified as follows: $\mu_n C_{ox} = 2.5\mu_p C_{ox} = 250\mu A/V^2$; V_{tn} = $|V_{tp}|$= 0.5V, V_{An} = $|V_{Ap}|$ = 10 V. Specify the required value of R and the W/L rations for transistors. Also specify L_D and $|V_{GS}|$ at which each transistor is operating. For dc bias calculations you may neglect channel-length modulation.