Department of Electrical Engineering
Indian Institute of Technology, Kanpur

EE 210 **Assignment #5** **Assigned: 8.2.21**

1. Consider the 4-resistor bias network for BJTs, as discussed in class. Assume V_{CC} = 12 V, β = 100, R_C = 4 kΩ, R_E = 4 kΩ, and the current through R_1 is 20 times the base current of the transistor.
   a) Using the simple analysis given in class, choose the required values of R_1 and R_2 such that the dc collector current is 1 mA. What is the value of V_{CE}?
   b) Now, using the values of R_1 and R_2 chosen in part a), perform an exact analysis of the circuit, and determine the actual values of I_C and V_{CE}. How do they compare with the results of part a)?

2. For the circuit shown in Fig.1, transistors Q_1 (β_1 = 100) and Q_2 (β_2 = 50) are operating in the forward active region. Find all the currents marked in the figure. Calculate V_{01} and V_{02}. Hence, determine V_{CE1} and V_{CE2}. Comment on the biasing.

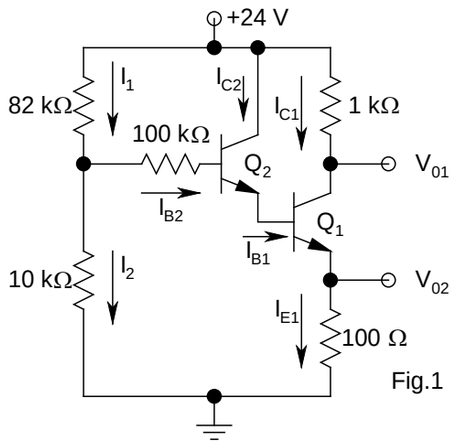

Fig.1

3. Consider the four resistor bias network for MOSFETs, as discussed in class. Assume V_{DD} = 5 V, R_S = 8 kΩ, and the body is tied to V_B = –1 V. The required dc quiescent drain current I_{DQ} = 200 μA, the dc quiescent power dissipation should not exceed 2 mW, and the circuit should be under the ***best biasing***. Determine the required values of R_1, R_2, and R_D. Data: V_{TN0} = 1 V, (W/L) = 10, k'_N = 40 μA/V^2, γ = 0.4 V$^{1/2}$, and $2\phi_F$ = 0.6 V. Neglect the channel length modulation effect.

4. Perform a self-consistent analysis (i.e., without assuming that V_{BE} = 0.7 V) of the simple BJT current mirror discussed in class, and determine the reference current I_{REF} and the output current I_0, neglecting the base width modulation effect, and assuming V_{CC} = 5 V and R = 4.3 kΩ. Assume that the transistor saturation currents I_{S1} = I_{S2} = 10^{-16} A, and the current gains β_1 = β_2 = 50. Now, assuming that the Early voltage V_{A2} of transistor Q_2 is 100 V, determine I_0 and the corresponding value of the output resistance R_0 of the mirror.

5. Design (i.e., calculate the required values of the aspect ratios of the two transistors) a simple MOSFET current mirror discussed in class, and find the value of the resistor R, such that the output current is at least 50 μA for V_0 as low as 0.1 V, and the current in the reference branch is 100 μA: i) neglecting body effect, and ii) assuming that the bodies of M_1 and M_2 are connected to –1 V and –2 V respectively. Comment on the answers. Assume V_{DD} = 5 V, the transistors are otherwise perfectly matched with k'_N = 40 μA/V^2, γ = 0.4 V$^{1/2}$, $2\phi_F$ = 0.6 V, and V_{TN0} = 0.7 V. For both parts, neglect the channel length modulation effect.