PROBLEM SET #6

Issued: Wednesday, Oct. 7, 2015

Due (at 8 a.m.): Wednesday, Oct. 14, 2015, in the EE 140/240A HW box near 125 Cory.

1. Provide an expression and calculate the numerical value for the output current mismatch between I_{C2} and I_{C3} shown in Fig. PS6-1 caused by finite fabrication tolerances.

Nominal Parameter Values:

$\beta = 100, I_s = 37.751\text{x}10^{-15}\text{A}, V_T = 25\text{mV}, R_0 = 3.4\text{k}\Omega, R_1 = R_2 = R_3 = 1\text{k}\Omega$

Fabrication Tolerances:

$\frac{\Delta\beta}{\beta} = 10\%, \frac{\Delta I_s}{I_s} = 5\%, \frac{\Delta R}{R} = 20\%$

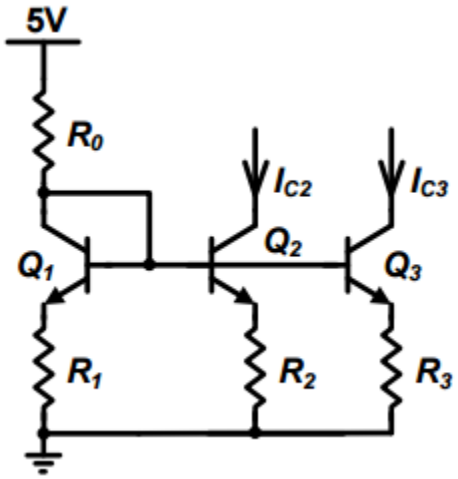


Fig. PS6-1

2. This problem considers the MOS current mirror shown in Figure PS6-2a.

(a) Design the current mirror such that all of the following is satisfied:

i. The currents $I_{D2} = 0.5\text{mA}$ and $I_{D3} = 2\text{mA}$, approximately.

ii. The minimum output voltage for which M_2 and M_3 work as current sources is 200mV.

iii. The output currents change less than 1% for a 1V change in output voltages.

iv. All transistors have the same channel length.

You are to minimize the total circuit area approximately given by:

$$A = \sum_{i=1}^{3} W_i L_i + \beta R_1$$

The parameter λ can be calculated as $\lambda = \alpha / L$. α and β are constants.

Transistor Parameters:

$$\alpha = 0.02\frac{\mu\text{m}}{\text{V}}, \beta = 0.2\frac{\mu\text{m}^2}{\Omega}, C_{ox} = 5\frac{\text{fF}}{\mu\text{m}^2}, \mu_n = 450\frac{\text{cm}^2}{\text{Vs}}, V_{th} = 0.6\text{V}$$

(b) A layout designer used long and narrow wires to connect sources of M_1, M_2, and M_3 which resulted in small parasitic resistors $R_p = 2\Omega$ as shown in Fig. PS6-2b. What are the new values of I_{D2} and I_{D3}? You can use numerical methods if needed.

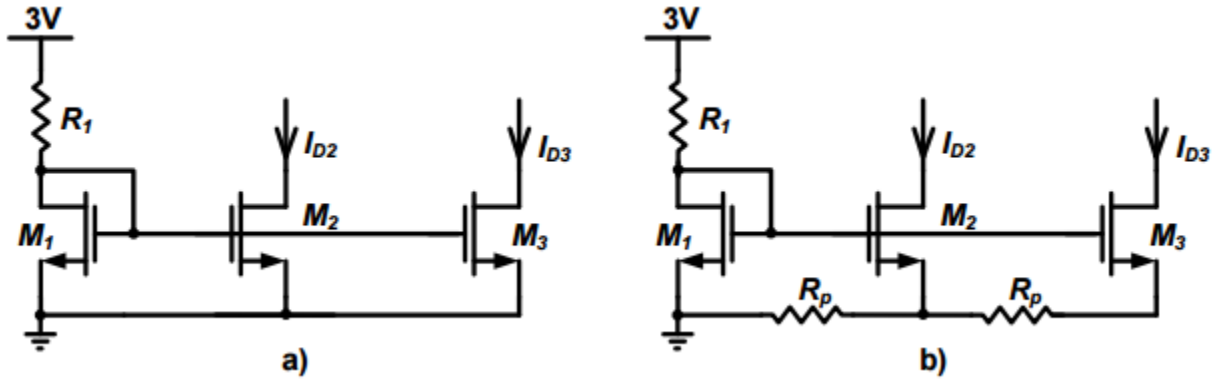


Fig. PS6-2

3. Calculate the mid-band gain and input resistance of the amplifiers shown in Fig. PS6-3 assuming β=100.

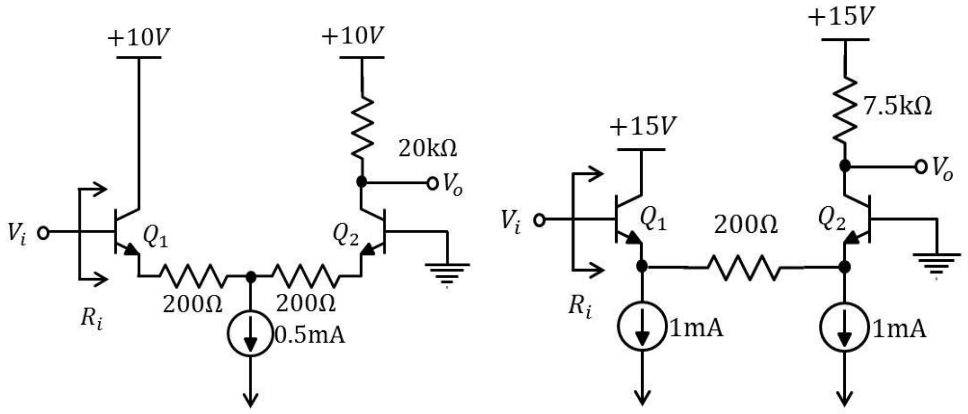
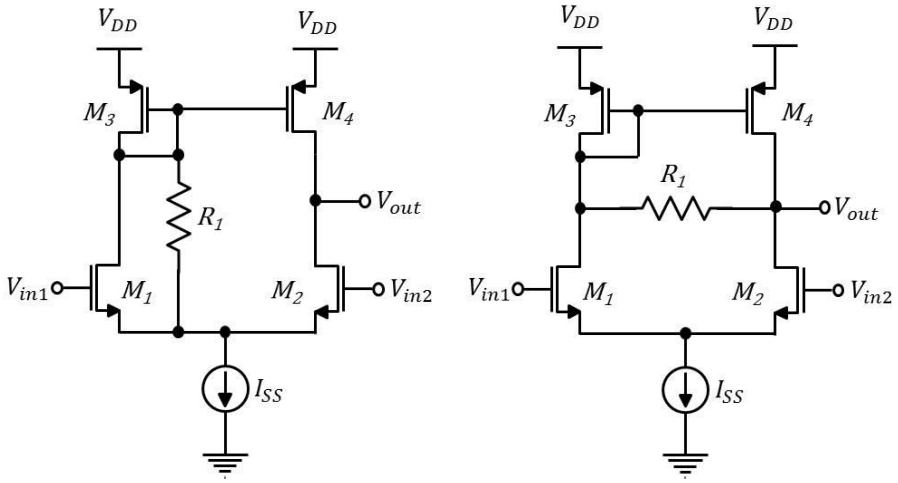


Fig. PS6-3

4. Due to a manufacturing defect, a large parasitic resistance R_1 has appeared in the circuits of Fig. PS6-4. Assuming all transistors are in saturation, find an expression for the mid-band gain $G = V_{out}/(V_{in1} - V_{in2})$ of each circuit. The expressions should be in terms of the given elements and parameters of the small-signal equivalent circuits (i.e., g_m, r_o etc.) for the transistors. Ignore body-effect.



(a) (b)

Fig. PS6-4