# Exercises for Tutorial 2: Differential Amplifiers

1. Problem 4.18 in the course book (Only for Fig. 4.38. Assume $\gamma = 0$. For Fig. 4.38(a) assume $r_o \gg R_1$ and $r_o \gg 1/g_m$. Also in Fig. 4.38(e), assume $\lambda = 0$).

2. Problem 4.22 in the course book.

3. Problem 5.3(a) in the course book for $\gamma = 0$. Assume all the transistors are in the saturation region and $\mu_n C_{ox} = 4\mu_p C_{ox} = 200\,\mu A/V^2$, $V_{tn} = |V_{tp}| = 0.5\,V$ and $V_{DD} = 2.5\,V$.

4. Calculate the small-signal voltage gain of the cascade differential pair shown in Figure 3.Assume $\gamma = 0$.

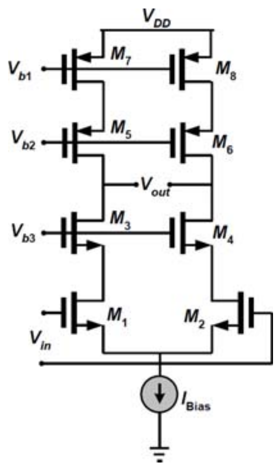


Figure 3 A differential amplifier.

5. Consider the differential amplifier shown in Figure 4. Due to a manufacturing defect, a large parasitic resistance has appeared between the drains of $M_1$and $M_4$. Assume $\lambda = \gamma = 0$. Calculate the small-signal gain, common-mode gain, and CMRR. Assume that $\left(W/L\right)_1 = \left(W/L\right)_2$ and $\left(W/L\right)_3 = \left(W/L\right)_4$.

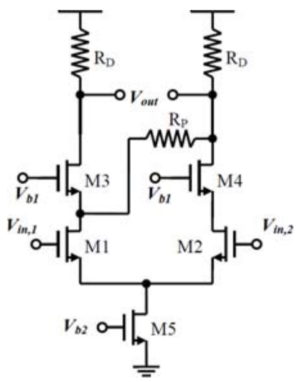


Figure 4 A differential amplifier.

6. A simple current mirror is shown in Figure 5. Calculate the value of $V_{bias}$ in order to have $V_N = {}^{V_{DD}}/_{2}$. Using this value calculate the error percentage of mirroring. Error percentage can be defined as $E(\%) = \frac{|I_{ref} - I_{out}|}{I_{ref}} \times 100$.

$$\mu_n C_{ox} = 200 \frac{\mu A}{V^2}$$

$$\mu_p C_{ox} = 50 \frac{\mu A}{V^2}$$

$$V_{DD} = 3\ V$$

$$\left(\frac{W}{L}\right)_3 = 4\left(\frac{W}{L}\right)_1 = 4\left(\frac{W}{L}\right)_2 = 20$$

$$R = 1\ k\Omega$$

$$V_{tn} = |V_{tp}| = 0.5\ V$$

$$\lambda_n = |\lambda_p| = 0.1\ V^{-1}$$

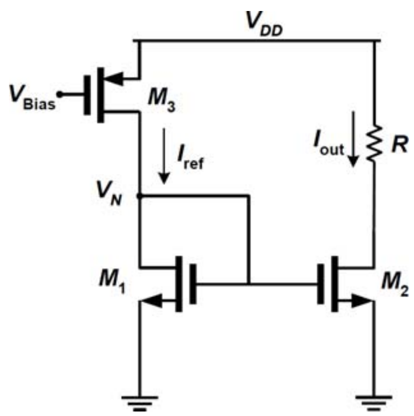


Figure 5 Simple current mirror.