# PROBLEM SET #9

*Issued: Tuesday, April 7, 2009*

*Due: Tuesday, April 14, 2009,* **5:00 p.m.** in the EE 140 homework box in 240 Cory

**1.** An amplifier has low-frequency forward gain of 40,000, and its transfer function has three negative real poles with magnitudes 2 kHz, 200 kHz, and 4 MHz.

**(a)** If this amplifier is connected in a feedback loop with a constant feedback factor $f$ and with low-frequency gain $A_0$=400, estimate the phase margin;

**(b)** Repeat (a) if $A_0$=200 and then 100.

**2.** The amplifier $a(s)$ is has DC gain of 10,000 and three real negative poles. The pole frequencies of the first and the third pole are 1 kHz and 200 MHz, respectively.

**(a)** If $R_1$=$R_2$ find the location of the second pole such that the feedback amplifier shown in Figure PS9-2 is stable with a phase margin of 60$^o$. Neglect the input impedance of the amplifier.

**(b)** Write the transfer function in as a function of the complex variable $s$ and draw Bode plots for the open-loop amplifier gain $a(s)$ and the closed-loop gain $A(s)$.

**(c)** What is the new phase margin if:

i. In addition to the three poles the amplifier $a(s)$ has one real right half-plane zero at the frequency of the second pole.

ii. In addition to the three poles the amplifier $a(s)$ has one real left half-plane zero at the frequency of the second pole.

iii. The closed-loop amplifier $A(s)$ is configured as a unity gain buffer.

iv. $R_1$=9$R_2$.

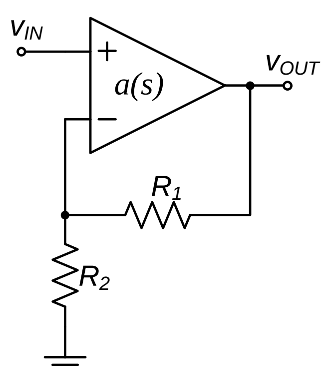


Figure PS9-2

**3.** Razavi, Chapter 10: Problem 10.4.

**4.** In the amplifier shown in Figure PS9-4 transistors $M_3$-$M_8$ are biased with $V_{ov}$=200mV. The gates of $M_3$ and $M_4$ are biased to allow the maximum undistorted sinusoidal signal at the output. Calculate all currents, channel widths and the value of capacitor $C_c$ so that the amplifier has a DC gain of 20, a unity gain frequency of 50MHz, and a phase margin of 60° when placed in unity gain closed-loop feedback. All transistors have the same channel length. Neglect all parasitic capacitances in this problem.

$$V_{DD} = 3V,\ R_L = 10k\Omega,\ C_L = 5pF$$

$$V_{th0,n} = 0.5V,\ \mu_n C_{ox} = 250\frac{\mu A}{V^2},\ L = 0.5\mu m,\ \lambda = 0,\ \ \gamma = 0,\ L_d = 0$$

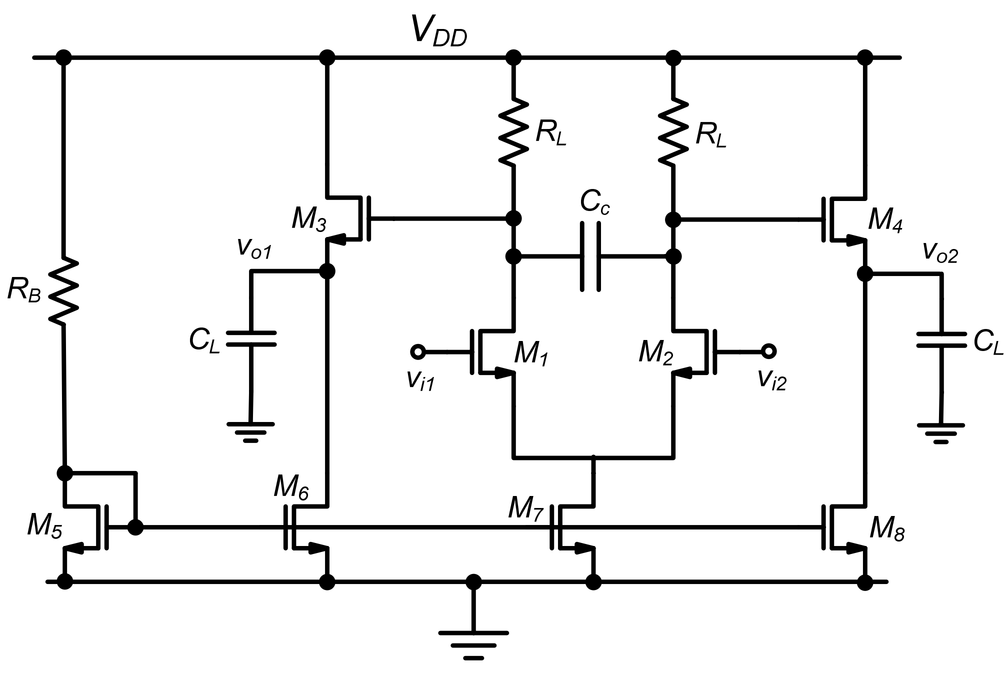


Figure PS9-4