Homework 7

Due: Friday, 14 March 2014 at 1pm

This is an individual assignment!

PROBLEM 1 (20pts):
Consider a two-pole op amp with a DC gain of 40dB, and with its poles at $\omega p1=\omega 0$ and $\omega p2=100\times\omega 0$. The input and output impedances of the op amp are large and small enough, respectively, to be negligible. Using this op amp, we construct the feedback systems shown in Figure 1.
1) For each system in Figure 1, sketch the Bode plots of the open-loop amplifier $A(j\omega)$ (amplitude and phase) with $20\log_{10}(1/|f(j\omega)|)$ overlay (where $f(j\omega)$ is the feedback factor). Determine the Gain margin (GM) and Phase margin (PM) in each case.
2) For each system in Figure 1, find the closed-loop transfer function $A_{CL}(s)=Vout(s)/Vin(s)$ and sketch the Bode plots (amplitude and phase) of the closed loop.

You may make reasonable approximations in your sketches, but do label all gain, pole/zero locations, and slopes. For part (c), assume $1/(RC) << \omega_0/100$.

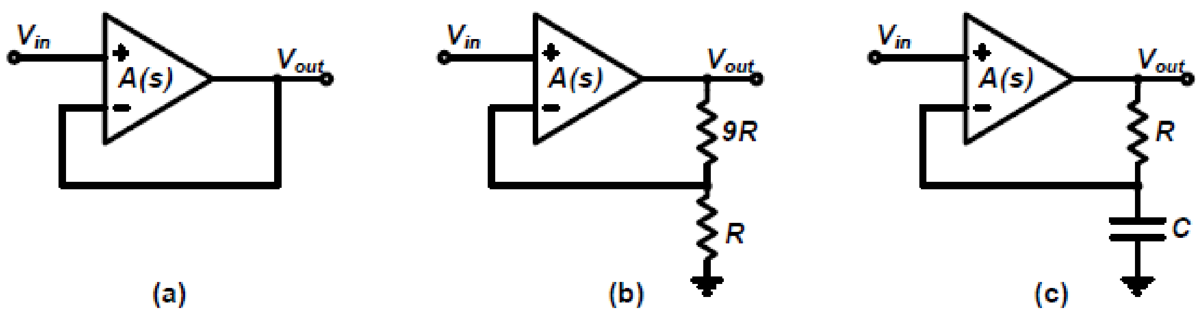

Figure 1

PROBLEM 2 (10pts):
An amplifier has a low-frequency forward gain of 5000 and its transfer function has three negative real poles with magnitudes 300 kHz, 2 MHz, and 25 MHz.
(a) Calculate the dominant-pole magnitude required to give unity-gain compensation of this amplifier with a 45^o phase margin if the original amplifier poles remain fixed. What is the resulting bandwidth of the circuit with the feedback applied?
(b) Repeat (a) for compensation in a feedback loop with a closed-loop gain of 20 dB and 45^o phase margin.

PROBLEM 3 (20pts):
For the amplifiers shown in Figure 3, provide expressions for the gain, output resistance and high-frequency cut-off f_H, in terms of transistors small-signal parameters (i.e. g_m, r_o, C_{gs}, C_{gd}, C_{db}, C_{sb}) for common-mode and differential-mode input. Neglect the body effect.

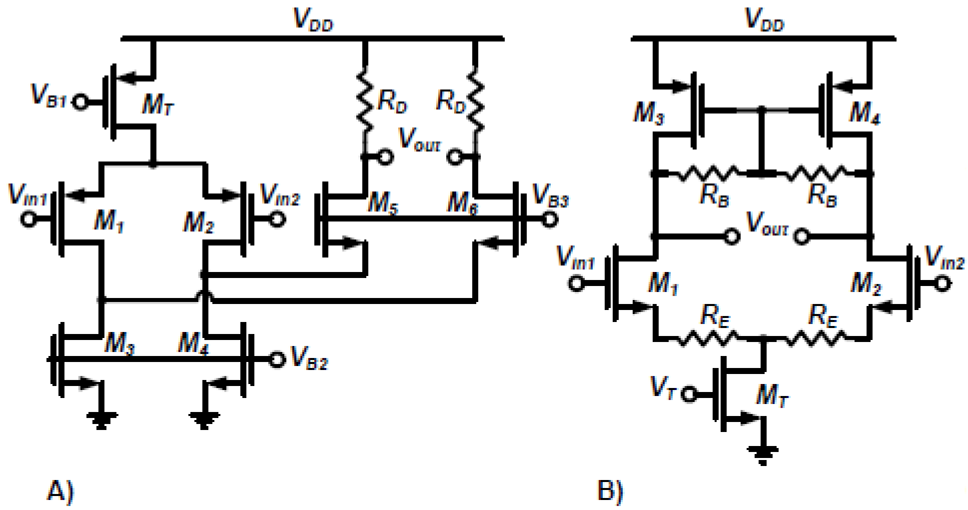

Figure 3

EXTRA PROBLEM FOR EE 240A STUDENTS:
PROBLEM 4 (20pts):

An op amp with low-frequency gain of 20log10(a_0)=108dB has three negative real poles with magnitudes 30 kHz, 500 kHz, and 10 MHz before compensation.
The circuit is compensated by placing a capacitance across the second stage, causing the second most dominant pole to become negligible because of pole splitting. Assume the small-signal transconductance of the second stage is 6.39 mA/V and the small-signal resistances to ground from the input and output are 1.95 MΩ and 86.3 kΩ, respectively. Calculate the value of capacitance required to achieve a 60° phase margin in a unity-gain feedback connection (f=1) and calculate the frequency ω_0 where the resulting open-loop gain a(j ω_0) = 0 dB. Assume that the pole with magnitude 10 MHz is unaffected by the compensation.