PROBLEM SET #10

Issued: Tuesday, Nov. 12th, 2013

Due: Wednesday, Nov. 20th, 2013, 8:00 a.m. in the EE 140/240A homework box

1. An amplifier with a forward gain of A_0 has two coincident poles at ω_p.

(a) Calculate the maximum value of A_0 for a 60° phase margin with a closed-loop gain of (i) unity and (ii) 4.

(b) Repeat part (a) assuming that you compensated the amplifier such that $\omega_{p1} = \omega_p/50$ and $\omega_{p2} = \omega_p$.

2. A dc amplifier has an open-loop gain of 1000 and two poles: a dominant one at 1MHz and a high-frequency one whose location can be controlled. It is required to connect this amplifier in a negative-feedback loop that provides a dc closed loop gain of 100 and a maximally flat response. Find the required value of feedback factor (i.e., f) and the frequency at which the second pole should be placed.

3. Consider a two-stage two-pole op amp with open-loop transfer function $A(s) = \frac{a_0}{(1+s/\omega_{p1})(1+s/\omega_{p2})}$. Assume that a_0 = 60dB, and ω_{p1} is the dominant pole at the output and located at 2π×100kHz, G_{m1} = 10mS, G_{m2} = 5mS, R_{out1} = 5kΩ, R_{out2} = 4kΩ.

a. Find the value of ω_{p2} so that a unity gain feedback circuit using this op amp exhibits a 45° phase margin. Sketch the magnitude and phase Bode plots of the op amp's open-loop transfer function.

b. Let ω_{p2}=2π×10MHz for this and all remaining parts of this problem. Find the op-amp's unity-gain frequency and unity-gain phase margin. Sketch the magnitude and phase Bode plots of the op amp's open-loop transfer function.

c. Given what you found in part (b), is it safe to put this op amp into unity-gain feedback? Explain why or why not.

d. Derive an expression and find numerical value for the needed compensation capacitor C_c that provides a phase margin of 60° in unity gain feedback.

e. Derive an expression and find numerical value for the needed compensation capacitor C_c that provides a phase margin of 75° in unity gain feedback.

4. A two-stage op-amp has a compensation capacitor connected between the input and the output of its second stage. Assume that the frequency of its second-pole is 60MHz and that this frequency stays constant with changes in the compensation capacitor. Assume the input stage generates a transconductance of 0.775mA/V, and the second stage provides a voltage gain of 100. What is the required size of the compensation capacitor if the phase margin is to be 55^{o} for the feedback configuration as shown in Fig. PS10.4.

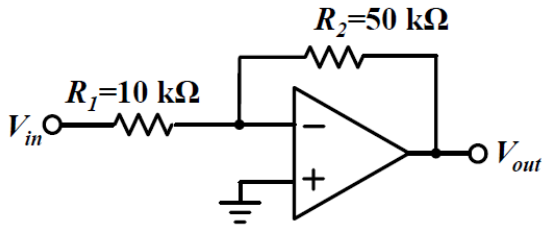

Fig. PS10.4