

## Homework 10

Due: Monday Dec. 8, 2014 1pm

1. An amplifier with a forward gain of  $A_0$  has two coincident poles at  $\omega_p$ .
  - (a) Calculate the maximum value of  $A_0$  for a  $60^\circ$  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  $a_0 = 60\text{dB}$ , and  $\omega_{p1}$  is the dominant pole at the output and located at  $2\pi \times 100\text{kHz}$ ,  $G_{m1} = 10\text{mS}$ ,  $G_{m2} = 5\text{mS}$ ,  $R_{out1} = 5\text{k}\Omega$ ,  $R_{out2} = 4\text{k}\Omega$ .
  - a. Find the value of  $\omega_{p2}$  so that a unity gain feedback circuit using this op amp exhibits a  $45^\circ$  phase margin. Sketch the magnitude and phase Bode plots of the op amp's open-loop transfer function.
  - b. Let  $\omega_{p2} = 2\pi \times 10\text{MHz}$  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  $60^\circ$  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  $75^\circ$  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  $55^\circ$  for the feedback configuration as shown in Fig. PS10.4.

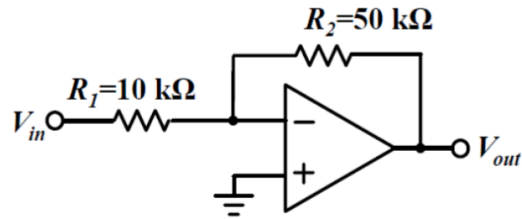


Fig. PS10.4