PROBLEM SET #10

Issued: Tuesday, Apr.10, 2012

Due: Tuesday, Apr.17, 2012, 6:00 p.m. in the EE 140 homework box in 240 Cory

1. An op amp has an open-loop transfer function given by $A(s) = \frac{a_0(1+S/\omega_z)}{(1+S/\omega_{p1})(1+S/\omega_{p2})}$. Here, a_o is the dc gain of the op amp. ω_z, ω_{p1} and ω_{p2} are the frequencies of the zero, the dominant pole, and the equivalent second pole, respectively. Assume that ω_{p2} = 2π×50 MHz and a_o = 10^4.

   (a) If $\omega_z \rightarrow \infty$, find the value of the dominant pole ω_{p1} and the unity-gain frequency ω_T, so that the phase margin is 55^o when the op amp is placed in unity-gain closed-loop feedback.

   (b) If $\omega_z = -0.1\ \omega_{p2}$, calculate and sketch the magnitude and phase Bode plots of the op amp's open-loop transfer function. What is the unity-gain frequency ω'_T? If the op amp in emplaced in a unity-gain feedback connection, will the resulting closed-loop circuit be stable? If it is stable, what is the phase margin? You can assume that ω_{p1}=5 kHz instead of the value found in part (a), so that your calculation won't be affected by the result from part (a).

   (c) If ω_z = +1.2 ω_T, calculate and sketch the magnitude and phase Bode plots of the op amp's open-loop transfer function. What are the new unity-gain frequency ω''_T and the new phase margin when the op amp is emplaced into a unity-gain feedback circuit? You can assume that ω_{p1}=5 kHz and ω_T =35 MHz.

2. 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. PS10.2

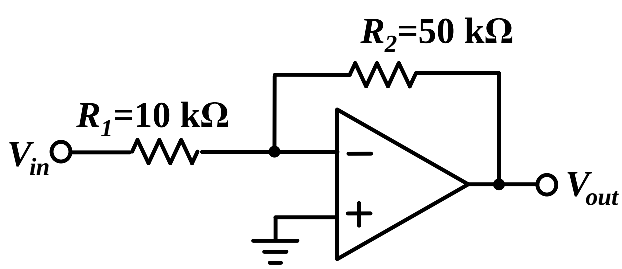

Fig. PS10.2

3. A two-stage op amp with a low-frequency gain of 100 dB has three negative real poles with magnitudes of 30 kHz, 500 kHz, and 20 MHz before compensation. The circuit is compensated by placing a capacitance across the second stage, causing the second most dominant pole to be at 40MHz due to pole splitting. Assume the small-signal transconductance of the second stage is 3 mS and the small-signal resistances at the output of the first and second stages are 1 MΩ and 47 kΩ, respectively. Calculate the value of

capacitance required to achieve a 60^o phase margin in a unity-gain feedback connection, and calculate the frequency where the resulting open-loop gain is 0 dB (unity gain bandwidth). Assume that the pole with magnitude 20 MHz is unaffected by the compensation.