PROBLEM SET #10

Issued: Thursday, Apr. 11, 2013

Due (at 8 a.m.): Friday, Apr. 19, 2013, in the EE 140/240A HW box near 125 Cory.

1. Consider a 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 located at 2π×100kHz.

a. Find the value of ω_{p2} so that the op amp would have a 45° phase margin in unity-gain feedback. 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.

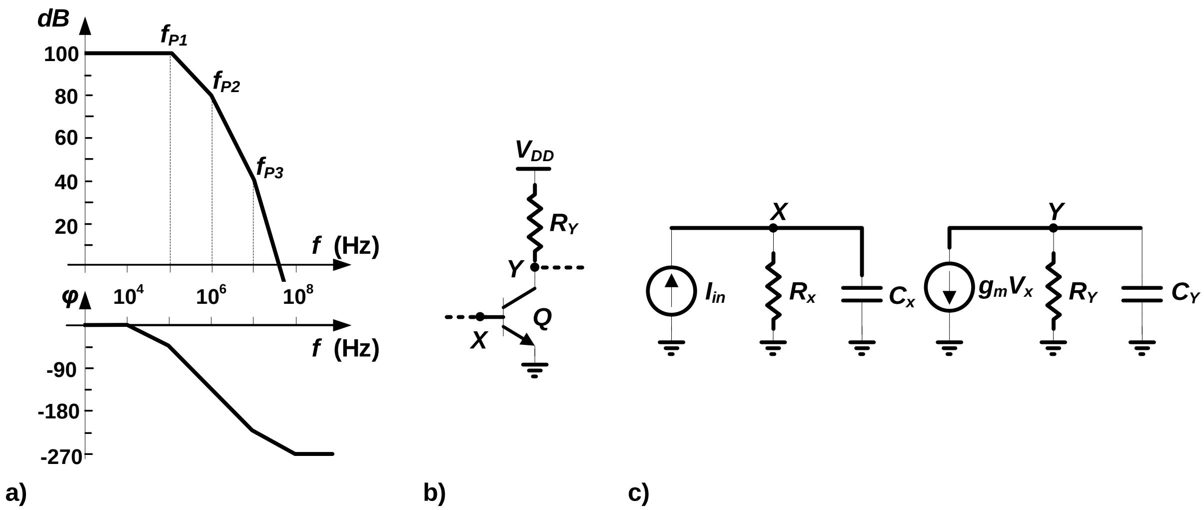
d. We would like to compensate the op amp by using a zero to cancel ω_{p2}, so that its open-loop transfer function is now $A(s) = \frac{a_0(1+s/\omega_z)}{(1+s/\omega_{p1})(1+s/\omega_{p2})}$, with $\omega_z=\omega_{p2}$. What is the compensated op amp's unity-gain frequency and unity-gain phase margin?

e. Realistically, we are unable to match ω_z and ω_{p2} exactly. Repeat part (d) for $\omega_z=2\times\omega_{p2}$ and $\omega_z=0.5\times\omega_{p2}$.

2. Consider an op amp whose open-loop transfer function is shown in Fig. PS10.2-a. Assume that the op amp circuit includes a stage such as that of Fig. PS10.2-b with C_x = 100pF, C_y = 5pF, and g_m = 40mA/V, that the pole at f_{P1} is caused by the input circuit of that stage, and that the pole at f_{P2} is introduced by the circuit output. Find the value of the compensating capacitor such that the closed-loop amplifier with resistive feedback is stable for any gain (i.e., for β up to unity) if the compensating capacitor is connected:

(a) between the input node *X* and ground,

(b) between *X* and *Y*, in the feedback path of the transistor.



3. 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 stats constant with changes in the compensation capacitor. Assume the input stage generates a transconductance of 0.70mA/V, and the second stage provides a voltage gain of 100. With the feedback configuration shown in Fig. PS10.3, determine the maximum amplitude of the circuit's closed-loop gain due to frequency peaking for the following compensation capacitances:

(a) 0.25pF

(b) 0.50pF

(c) 0.60pF

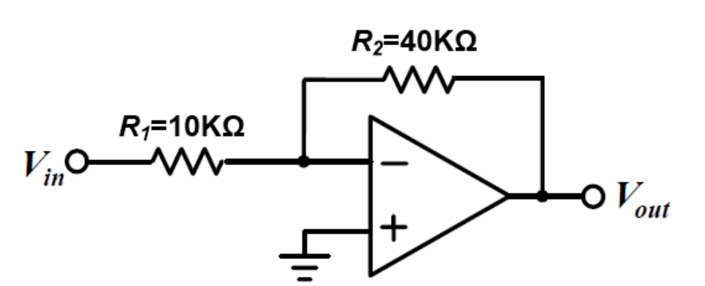


Figure PS10.3