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PROBLEM SET #10

Issued: Tuesday, April 12th, 2011
Due: Tuesday, April 19th, 2011, 5:00 p.m. in the EE 140 homework box in 240 Cory

1. A two-stage op amp with a low-frequency gain of 108 dB 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 (very high frequency) due to pole splitting. Assume the small-signal transconductance of the second stage is 6.39 mS and the small-signal resistances at the output of the first and second stages are 1.95 MΩ and 86.3 kΩ, respectively. Calculate the value of capacitance required to achieve a sixty degree 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 10 MHz is unaffected by the compensation.
2. Repeat problem 1 if the circuit is compensated by using a shunt capacitance to ground at the input of the second stage. Assume that this only affects the most dominant pole.

Reminder: The phase of a complex number is defined as the arctangent of the ratio of the imaginary and real components, and the magnitude is defined as the square root of the sum of the squares of the imaginary and real components. These components come out nicely if you write the transfer function of the op amp in the form…

$$a = \frac{a_0}{\left(1 + j\frac{f}{f_1}\right)\left(1 + j\frac{f}{f_2}\right)(\ldots)\left(1 + j\frac{f}{f_N}\right)}$$

… where f_1 through f_N are the dominant pole frequencies and f is the frequency at which you are calculating the gain. Remember also that a phase margin of 60 degrees means that the phase of the transfer function (actually, of the loop transmission) is -120 degrees.