ECE 423/523 – CMOS Integrated Circuits II

Problem Set #3

1. Analyze/show the pole-splitting and right-half-plane zero cancellation of a standard two stage structure. Use g_{m1}=0.01, g_{m2}=0.02, R_1=100kΩ, C_1=0.5pF, R_2=5kΩ, C_2=2pF, and sweep C_C & R_C. For pole-splitting, use R_C=0 and sweep C_C. For RHP zero cancellation, set an appropriate value for C_C (you decide what is reasonable) and sweep R_C. First do the mathematical derivation (third order with R_C included) of the compensated two-stage opamp, and then *numerically* solve for poles and zeros as a variable (R_C or C_C) is swept. You may find MATLAB command *roots* useful for this task. The derivation does not have to be simplified because you will be processing this numerically. Also, if you find a derived result in a textbook/web somewhere, and choose to use that instead, be sure that you understand it 100% clearly before using it.

1b. For the pole-splitting above, repeat with R_2=100kΩ, C_2=0.5pF, R_1=5kΩ, C_1=2pF (i.e. R_1C_1 and R_2C_2 are swapped). Explain what happens.

2. Analysis/show the movement of poles in a 3-pole opamp in *closed* loop, by sweeping the feedback factor β from 0 to 1. For the opamp, use $a_o=10^3$, $p_1=10^3$, $p_2=10^5$, and $p_3=10^6$.

3. Analyze 2-pole opamp closed loop settling for varied phase margin (PM) from 40° to 80° in 5° increment. Create columns of data for PM, $p_2/(a_op_1)$, % overshoot (time-domain), and dB magnitude peaking (frequency-domain). And produce two plots, one for % overshoot (time settling) and one for dB peaking (frequency response), overlaid for all PMs. Use fixed feedback factor β=1, open loop gain $a_o=10^6$ (ridiculously high gain), and p_1=1 for this analysis. You need to *iteratively* get each desired PM (within 0.1° precision) by moving p_2 while p_1 is fixed. Do *not* formulate/use closed-form equations. You may find MATLAB commands such as *tf*, *impulse*, *step*, and *freqs* useful for this task.

4. With $a_o=10^2$ (40dB) and $p_1=10^4$, use the same set of p_2 from #3 above to again generate the columns of data. Overshoot and peaking should get smaller. Why do you think that happens?

It is your responsibility to make sure you really understand any MATLAB functions 100% clearly before using any of them. Don't just use a function because the name sounds like it will do what you think, or just because some friend told you to use it. Do your own thing that you know and understand 100% clearly (e.g. I would avoid using *rlocus* command).