Homework 9 – Due Wednesday 11/7/2016

EEEE381 HOMEWORK FORMAT GUIDELINES

GENERAL: NEATNESS AND ORGANIZATION WILL BE GRADED. THE SAME GUIDELINES SHOULD BE FOLLOWED FOR EXAMS.

- ALL HOMEWORK IS TO BE HANDED ON ENGINEERING GRAPH PAPER or PLAIN WHITE PAPER (8.5 inch x 11 inch).
- NUMBER EACH PROBLEM INCLUDING CHAPTER IT COMES FROM
- HIGHLIGHT EACH FINAL ANSWER WITH A BOX AND INCLUDE APPROPRIATE UNITS.
- INCLUDE YOUR NAME ON EVERY PAGE
- ALL PROBLEMS SHOULD BE TURNED IN, IN ORDER!
- IF WORK IS NOT LEGIBLE, IT WILL NOT BE GRADED
- CROSS OUTS ARE NOT ACCEPTABLE. USE A PENCIL AND ERASER OR PEN AND WHITE-OUT. (Green-out?)
- PRESENT SOLUTION IN A FORMAT THAT PROCEEDS FROM LEFT TO RIGHT, TOP TO BOTTOM. IF ORGANIZATION OF SOLUTION IS NOT CLEAR, PROBLEM WILL NOT BE GRADED.
- PROVIDE A CONCISE DESCRIPTION OF YOUR METHOD OF SOLUTION. IF NONE IS PROVIDED, NO PARTIAL CREDIT WILL BE AFFORDED.
- PROVIDE AN APPROPRIATELY LABELED CIRCUIT DIAGRAM. IF CIRCUIT IS MODIFIED, INCLUDE MODIFIED DIAGRAM(S).
- MAKE SURE ALL PAGES ARE ATTACHED TO EACH OTHER SECURELY. STAPLES ARE A CLASSIC WAY TO DO THIS.
- -REMEMBER- HOMEWORK ASSIGNMENTS ARE NOT JUST ABOUT LEARNING TO DO THE PROBLEM. IT IS ABOUT LEARNING TO PRESENT YOUR WORK SO OTHERS CAN UNDERSTAND WHAT YOU DO - A VALUABLE SKILL IN THE WORKPLACE.

Things to remember

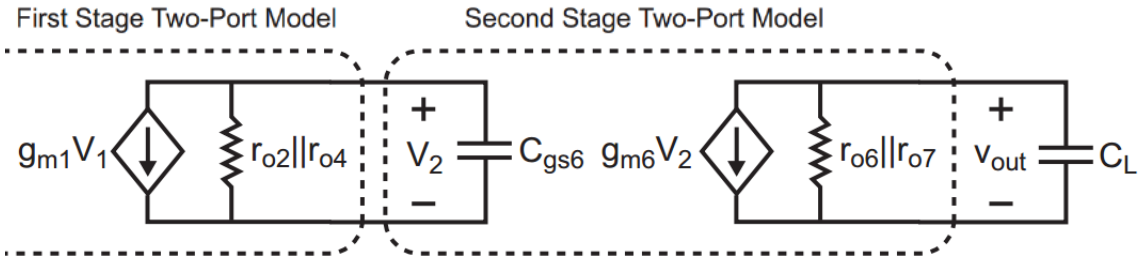
1) Re-Draw the Circuit on your homework sheet.
2) Show all work.
3) Final answer should be in decimal form.
4) Final answers should be boxed.
5) Your name should be on every page.

1) Draw the Bode plot magnitude of the following transfer function. Make sure to label the values of the slopes as well as the dB levels of all horizontal slopes.

$$H(s) = 10^3 \frac{(s+1500)(s+2\times10^5)^2}{s(s+3000)(s+10^4)}$$

Partial solutions: $|H(s\rightarrow\infty)|$ = 60 dB, $|H(s\rightarrow0)|$ ~ 186 dB

2) Draw the Bode magnitude and phase plot of the following simplified 2-stage CMOS amplifier. With g_{m1} = Gm= 5 mS, $r_{o2}//r_{o4}$= R_{o1} = 100 Kohm, C_{gs6} = C_1 = 50 pF, g_{m6} = 1.3 mS, $r_{o6}//_{ro7}$ = R_{02} = 45 kohm, C_L = C_2 = 30 pF. Find the angular frequency at 0dB gain. Find the phase angle at the 0dB gain angular frequency. Is this amplifier stable? Make sure to label the values of the slopes as well as the dB levels and phases of all horizontal slopes.

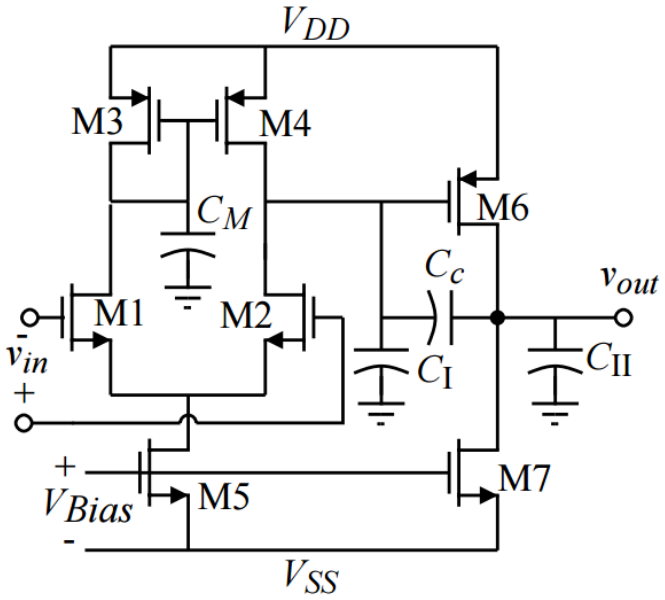


Partial solutions: A_M= 29,250 V/V = 89.32 dB, ωp1=2E5 r/s, ωp2=7.4E5 r/s, ω0dB = 6.57E7 r/s (-180°)

3) Use pole splitting and add a compensation capacitor Cc to the previous amplifier so that it provides a phase margin of 30°.
   a) Draw the simplified equivalent circuit including Cc.
   b) Find ω_{P2}.
   c) Choose phase margin (30° in this case).
   d) Find ω at which angle = (-180°+phase margin).
   e) Make gain = 0 dB in magnitude plot at ω found in d)
   f) Find ω_{P1}.
   g) Calculate Cc.
   h) Draw the new Bode magnitude and phase plots indicating the phase margin.

Partial solutions: ωp2=1.625E7 r/s, ω0dB = 3.5E7 r/s (-150°), ωp1=2.578E3 r/s, Cc=66.3pF

FYI: below shows the implementation of a miller compensation capacitor on a 2-stage CMOS amplifier. We have ignored C_M in our analysis.



C_c = accomplishes the Miller compensation

C_M = capacitance associated with the first-stage mirror (mirror pole)

C_I = output capacitance to ground of the first-stage

C_{II} = output capacitance to ground of the second-stage