EE140/240A Problem Set 8

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For all the problems in this homework, assume $\mu_n C_{ox} = 0.5\text{mA/V}^2$, $V_{Tn} = 0.3\text{V}$, for the NMOS transistors, assume $\mu_p C_{ox} = 0.4\text{mA/V}^2$, $V_{Tp} = 0.4\text{V}$, for the PMOS transistors. Also, assume that the channel length modulation parameter $\lambda = 0$, unless otherwise mentioned. Numbers adjacent to the MOS transistors indicate the (W/L) ratio of the transistors.

Problem 1. 4+3 points In lecture, we looked at the stability of a 3-stage amplifier. In this problem, you will re-derive those results. Assume you have an amplifier whose gain is given by

$$A(s) = \frac{A_0}{1 + \frac{s}{\omega_0}} \tag{1}$$

Now, we cascade three of these amplifiers and connect the cascaded three-stage amplifier in unity gain negative feedback.

(a) What is the maximum value of A_0 for which the system in unity gain feedback is stable?

(b) What is the frequency of the poles at this value of A_0?

Problem 2. 5+5+4 points Consider the amplifier shown below, which is very similar to the problem in Midterm 2, but also includes the parasitic capacitance C_E at node Y. Assume $V_{DD} = 2\text{V}$, $V_B = 1\text{V}$, $V_{B1} = 0.5\text{V}$. Also, assume that $C_L = \frac{1}{2\pi}\text{pF}$, $C_E = \frac{0.2}{2\pi}\text{pF}$.

(a) How many poles are there in the loop gain LG(s) = $fA(s)$, where $A(s)$ is the open-loop gain and f is the feedback factor. What are their frequencies? Note that the circuit is configured for unity gain feedback.

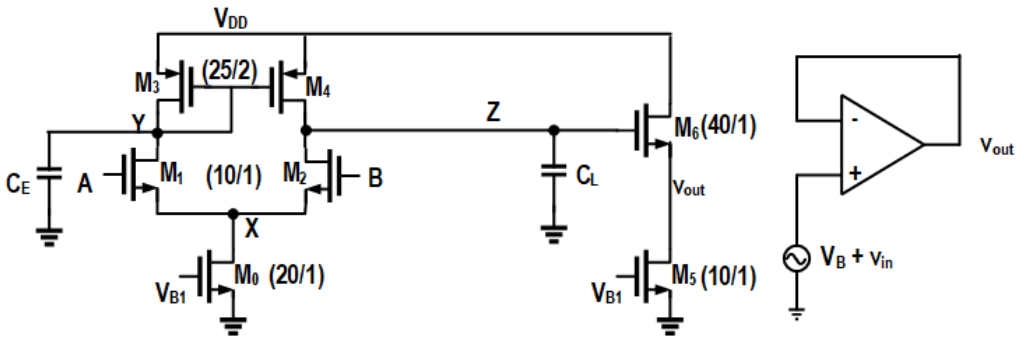

Figure 1: Problem 2

(b) The loop gain function LG(s) = $fA(s)$ also has a zero. Compute its frequency. To compute the zero frequency, find the short circuit current and note that the short circuit current has two paths to the output, with different frequency dependence. What is the relationship of the zero frequency with the non-dominant pole frequency?

(c) For this circuit in unity gain feedback, compute the phase margin.

Problem 3. 5+5 points Assume you have an amplifier placed in unity gain feedback. The open loop gain of the amplifier is given by

$$A(s) = \frac{100}{\left(1 + \frac{s}{\omega_d}\right)\left(1 + \frac{s}{2\pi \times 10^{10}}\right)} \tag{2}$$

(a) What values of ω_d are needed for a phase margin of 60^o, 45^o and 30^o?

(b) Plot the step response of the closed loop transfer function in each of these cases. You may use "tf" function in Matlab to define your transfer function and "step" function to plot the step response. Alternatively, you may use any other computational software or Cadence.