EE 3444  
Problem set # 4  
Tuesday June 29, 2010

Read Chapter 8, Sections 8.1, 8.2, 8.3, 8.4

1. A direct coupled amplifier has a voltage gain = -100 at DC and has zeros at $10^6$ rad/s and at $\infty$. It has poles at $10^5$ rad/s and at $10^7$ rad/s.
   a) Write an expression for the amplifier gain function.
   b) Draw the magnitude Bode plot for this amplifier.
   c) Draw the phase Bode plot directly under the magnitude plot so that the frequencies in both plots line up.
   d) From the plots determine the approximate gain and phase at $5 \cdot 10^6$ rad/s
   e) Using the formula derived below, find the 3 dB frequency value, $\omega_H$, for this amplifier.

   For a general transfer function,
   $$H(s) = \frac{(1 + s/\omega_z1)(1 + s/\omega_z2)(1 + s/\omega_z3)\ldots(1 + s/\omega_zm)}{(1 + s/\omega_p1)(1 + s/\omega_p2)\ldots(1 + s/\omega_pm)}$$

   The squared magnitude of this function is equal to $1/2$ at $\omega_H$.

   $$\frac{1}{2} = \frac{(1 + \omega_H^2/\omega_z1^2)(1 + \omega_H^2/\omega_z2^2)\ldots(1 + \omega_H^2/\omega_zm^2)}{(1 + \omega_H^2/\omega_p1^2)(1 + \omega_H^2/\omega_p2^2)\ldots(1 + \omega_H^2/\omega_pm^2)}$$

   $$\approx 1 + \omega_H^2/\omega_z1^2 + 1/\omega_z2^2\ldots + 1/\omega_zm^2 + O(\omega_z^4)$$

   $$\approx 1 + \omega_H^2/\omega_p1^2 + 1/\omega_p2^2\ldots + 1/\omega_pm^2 + O(\omega_p^4)$$

   $$\omega_H = 1/\sqrt{1/\omega_p1^2 + 1/\omega_p2^2 + \ldots + 1/\omega_pm^2 - 2/\omega_z1^2 - 2/\omega_z2^2\ldots - 2/\omega_zm^2}$$

2. This is based on problem 8.14 in the text.

   a) Draw the high frequency, small signal equivalent circuit with the input on the left and the output on the right.
   b) Write down the nodal equations for this circuit that you would need to solve this circuit. You do not need to actually solve these equations.
   c) Find the expression for the mid band voltage gain.
   d) From the values given in part (d) of problem 8.14, determine the necessary value for $R_{bias}$. Use $V_{DD} = 15$ V.
   e) Do the Spice analysis of this circuit to determine the frequency response and the high frequency 3 dB frequency. Remember that in SPICE, CGSO = CGS/W and CGDO = CGD/W.

3. Problem 8.21 in text.
4. Problem 8.30 in text.
5. Problem 8.38 in text.