EE539: Analog Integrated Circuit Design; HW1

Nagendra Krishnapura (nagendra@iitm.ac.in)

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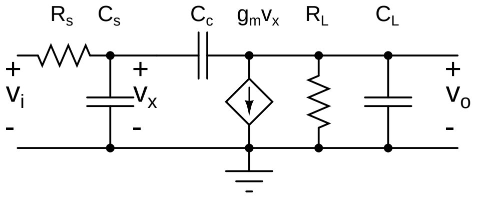

Figure 1: Problem 1

1. Calculate the transfer function $V_o(s)/V_i(s)$ in Fig. 1. Express it in the form $A_{dc}\frac{1+s()+\ldots}{1+s()+\ldots}$. Calculate the zeros and poles of the transfer function assuming that the poles are well separated[1].

   What is the phase shift at very low and very high frequencies?

   How do the poles and zeros change as $C_c \to 0$?

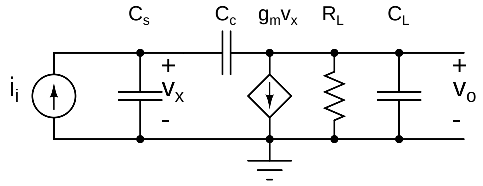

Figure 2: Problem 2

2. Calculate the transfer function $V_o(s)/I_i(s)$ in Fig. 2. Calculate the zeros and poles of the transfer function assuming that the poles are well separated[1].

3. Calculate the input impedance $Z_{in}(s)$ in Fig. 3. Do you see anything special? What is the input impedance with $g_m = 0$?

   Express $Z_{in}(s)|_{g_m \neq 0}$ as a parallel combination of $Z_{in}(s)|_{g_m=0}$ and another branch $Z_1(s)$. What does $Z_1(s)$ consist of?

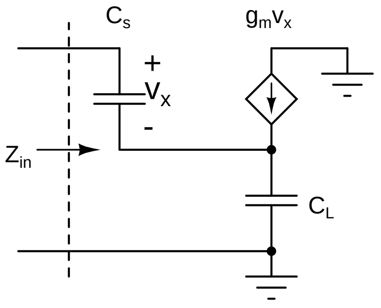

Figure 3: Problem 3

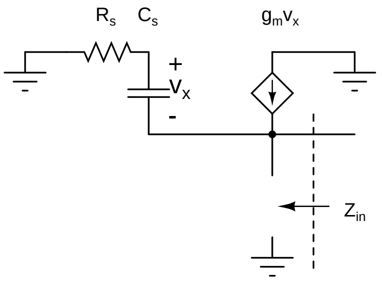

Figure 4: Problem 4

4. Calculate the input impedance $Z_{in}(s)$ in Fig. 4. Do you see anything special? Derive an equivalent circuit with passive elements that has an impedance Z_{in}.

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[1] For approximate solutions to the quadratic equation, refer to the handout

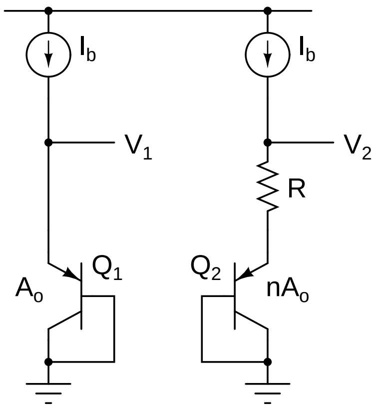

Figure 5: Problem 5

5. Calculate V_1 and V_2 as a function of I_b in Fig. 5. The bipolar transistors are modeled by ideal exponential behavior: $I_c = A_e J_s \exp(V_{BE}/V_t)$ where A_e is the emitter area and J_s is the saturation current density.

   Calculate I_{b0}, the value of I_b for which $V_1 = V_2$. What is the temperature coefficient of I_{b0}? If the transistors are biased at I_{b0}, what are their transconductances ($\partial I_c/\partial V_{BE}$)?

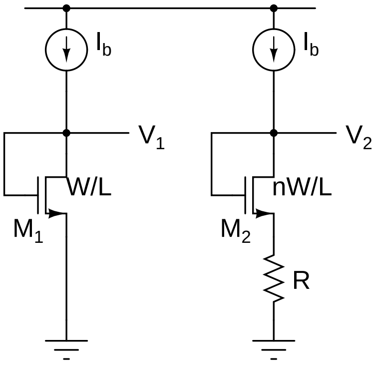

Figure 6: Problem 6

6. Calculate V_1 and V_2 as a function of I_b in Fig. 6. The MOS transistors are modeled by ideal square law behavior: $I_D = (\mu C_{ox}/2)(W/L)(V_{GS} - V_T)^2$.

   Calculate I_{b0}, the value of I_b for which $V_1 = V_2$. If the transistors are biased at I_{b0}, what are their transconductances ($\partial I_D/\partial V_{GS}$)?

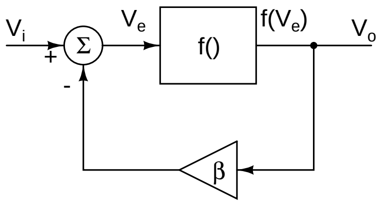

Figure 7: Problem 7

7. Fig. 7 shows a nonlinearity f enclosed in a negative feedback loop with a feedback fraction β. The transfer characteristic of the overall system is denoted by g, i.e. $V_o = g(V_i)$. Calculate the first four terms of the Taylor series of g about the operating point of the circuit in terms of f and its derivatives. Assume that $f(0) = 0$. What do you infer from the results?