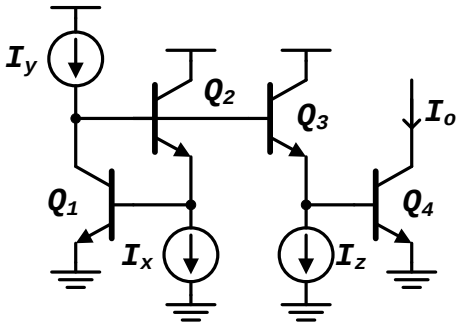
University of Michigan
EECS 522: Analog Integrated Circuits
Winter 2009

Problem Set 4

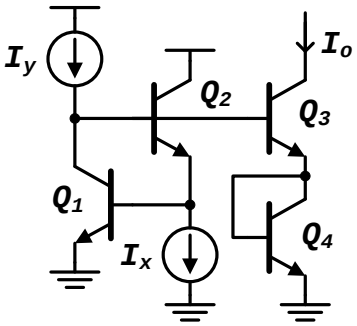
Issued 3/4/2009 – Due 3/11/2009

Problem 4.1: Find expressions relating the large-signal output current I_o to the other current sources in the circuits below. You may ignore base current. You may also find the following reference useful:
B. Gilbert, "Translinear circuits: a proposed classification," *Electronics Letters*, Vol. 11, No. 1, Jan. 1975, pp. 14-16.

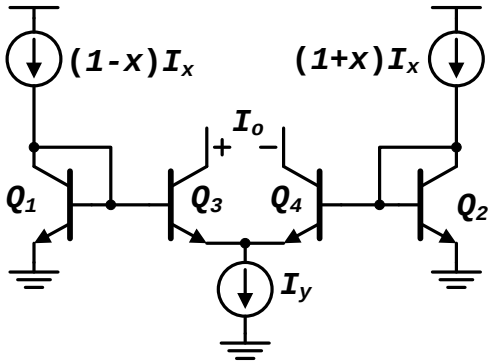
a)



b)



c)



Problem 4.2: For this problem, assume an amplifier with harmonic distortion terms up to 3rd order, and all higher order terms may be neglected: $v_{out} = \alpha_1 v_{in} + \alpha_2 v_{in}^2 + \alpha_3 v_{in}^3$. The gain of the amplifier is 10dB, and HD_3 is -40dB, measured at an input level of -15dBm in a 50Ω environment.

a) Estimate IM_3 of the amplifier at an input power level of -15dBm.

b) Assuming the input power was measured in a 50Ω environment; find the values of α_1 and α_3 for the amplifier.

c) Sketch a generic plot of the 3rd-order intercept point. Calculate the values of IIP3 and OIP3.

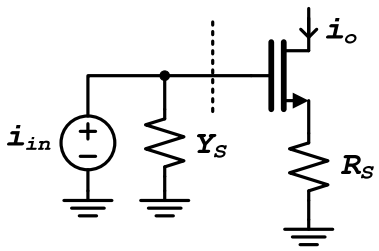
Problem 4.3: For this problem, assume an amplifier with harmonic distortion terms up to 3rd order, and all higher order terms may be neglected: $v_{out} = \alpha_1 v_{in} + \alpha_2 v_{in}^2 + \alpha_3 v_{in}^3$. The gain of the amplifier is 10dB, and HD_2 is -20dB, measured at an input level of -20dBm in a 50Ω environment.

a) Calculate the DC offset in Volts at the output due to the 2nd-order harmonic distortion in the amplifier at an input level of -20dBm.

b) What input level in dBm is required to reduce the DC offset at the output to 1mV.

Problem 4.4: You are given that an amplifier has a measured HD2, HD3, and HD4 of -30dB, -40dB, and -50dB, respectively. Assuming there are no other significant harmonics, calculate the THD in percent.

Problem 4.5: Use the circuit on the right for this problem. Consider only thermal noise in R_S, drain thermal noise in the FET, and correlated gate noise in the FET. You may neglect body effect and channel length modulation. Include C_{GS}, but ignore all other caps.



a) Find expressions for the input referred short-circuit noise voltage and open-circuit noise current of the amplifier (not including Y_S).

b) Find expressions for $B_{S,opt}$ and $G_{S,opt}$ ($Y_S = G_{S,opt} + B_{S,opt}$) that results in minimum noise factor. Your answer should be in terms of the intrinsic noise sources, and should be simplified. You may assume correlation coefficient c is imaginary and negative as we did in lecture.

c) Find an expression for the noise factor when $Y_S = 1/50\Omega$. Your answer should be in terms of the intrinsic noise sources, and should be simplified.