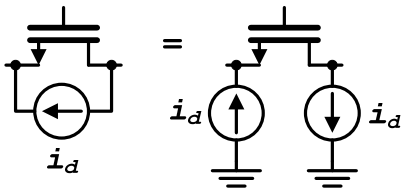
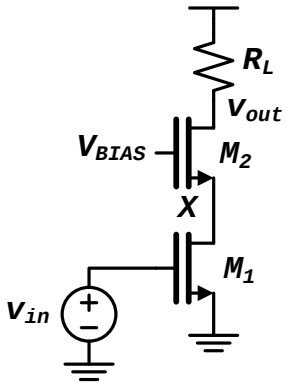
University of Michigan
EECS 522: Analog Integrated Circuits
Winter 2009

Problem Set 3

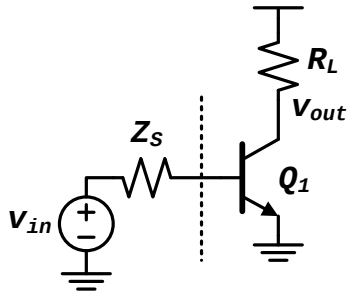
Issued 2/4/2009 – Due 2/18/2009

Problem 3.1: Use the circuit to the right for this problem. Ignore channel length modulation ($\lambda = 0$). All devices are in saturation. Consider only drain thermal noise in the FETs (no thermal noise in R_L). Find an expression for the input referred noise voltage neglecting induced gate noise. How does M_2 affect the noise contributed by the circuit?
Hint: the following circuit transformation may be useful.





Problem 3.2: Use the circuit to the right for this problem. Assume the BJT is in the forward active region, ignore r_o and r_b. Consider only shot noise in the collector and base (no thermal noise in R_L). Assume β is constant with frequency.



a) Derive expressions for the input-referred short-circuit noise voltage and open-circuit noise current (not including Z_S).

b) Derive an expression for the correlation admittance Y_c.

c) Derive expressions for the 4 noise parameters Gc, Bc, Rn, and Gu.

d) Find the source impedance resulting in minimum noise factor and evaluate is assuming $I_{C1} = 1mA$ and $\beta_F = 100$.

Problem 3.3: Suppose you have a choice between two amplifiers, both having 10nV/√Hz input noise voltage density; however, amplifier A has 50fA/√Hz input noise current density and amplifier B has 100fA/√Hz.

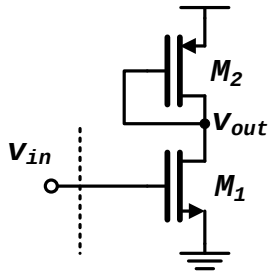
a) What is the optimum source resistance (resulting in lowest noise factor) for each amplifier? Assume the input noise sources are uncorrelated.

b) If the source resistance is 100kΩ, which amplifier should you use for lowest noise?

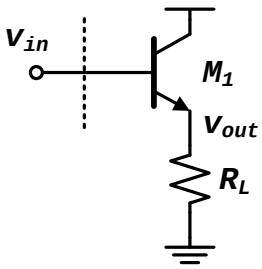
c) For your choice in part b), what is the noise factor?

Problem 3.4: Find expressions for the mean-square input referred short-circuit noise voltage and open-circuit noise current for the following circuits. You may neglect r_o and g_{mb}, and r_b. Include only drain noise in FET's, thermal noise in R's, and base and collector shot noise in BJT's.

a)



b)



c)