University of Michigan
## EECS 522: Analog Integrated Circuits
Winter 2009

Problem Set 5

Issued 3/18/2008 – Due 3/25/2008

Problem 5.1:   Final project deliverables.

a) Schedule a time for your final project group to meet with Prof. Wentzloff between 12-3pm on Monday March 10. During this meeting, we will discuss what you will do for your final project. Come prepared with ideas and any relevant journal or conference publications.

b) Send a title and abstract for your final project to Prof. Wentzloff (wentzlof@umich.edu) by Wednesday March 12. The abstract should be less than 150 words. Make sure to include any references to relevant publications in your abstract.

**Problem 5.2:**   The block diagram below is for a single-sideband (SSB) AM modulator.
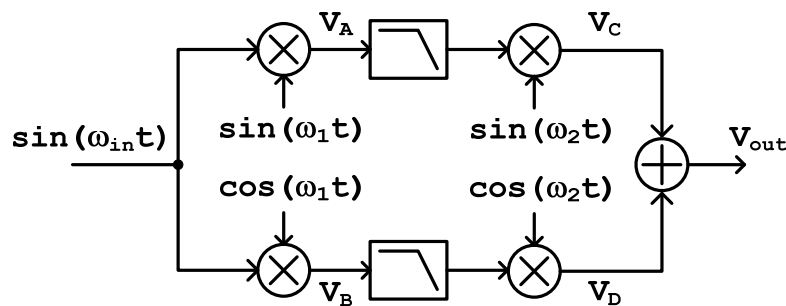
a) Assuming $\omega_2 \gg \omega_1 \gg \omega_{in}$, derive expressions for and sketch the spectrum of the signal at V_A, V_B, V_C, V_D, and V_{out}. The cutoff frequency of the low-pass filter is ω_1.

b) What is the frequency of the signal at the output?

Problem 5.3:   The RC-CR filter shown on the right can be used to generate quadrature (sin and cos) tones from a single oscillator.

a) Derive expressions for the phases of the two outputs V_I and V_Q. Sketch the two phases on a single graph.

b) At what frequency is the phase difference between V_I and V_Q equal to 90 degrees?

c) What is the amplitude of V_I and V_Q at the frequency found in part b) for an input $V_{LO} = V_A\cos(\omega_{LO}t)$?
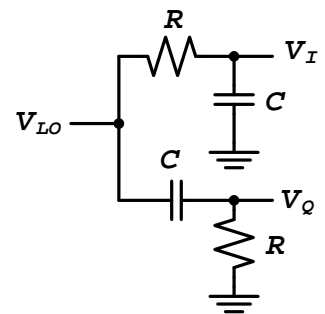
Problem 5.4: For this problem, use the circuit on the right. Assume that all transistors are matched, and that C is the only capacitance in the circuit. Consider only drain thermal noise in the FETs and thermal noise in the resistor. Find an expression for the frequency dependent input referred noise.
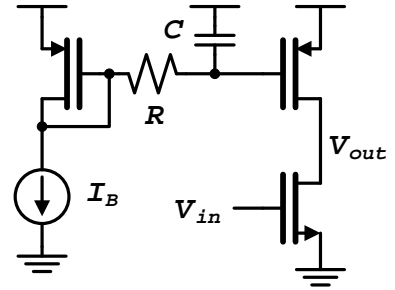
Problem 5.5: The problem looks at the noise performance of a transimpedance amplifier, commonly used when interfacing to photo diodes.

a) For this part, use the transimpedance amplifier shown on the right. Assume the amplifier is noiseless. Find an expression for the input referred noise current and output referred noise voltage considering only thermal noise in the resistor.
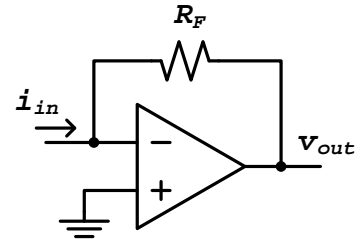
b) Now consider an amplifier with equivalent input noise generators v_a^2 and i_a^2. Find a new expression for the input referred noise current also considering thermal noise in the resistor.

Hint: remember that v_a and i_a may be correlated.