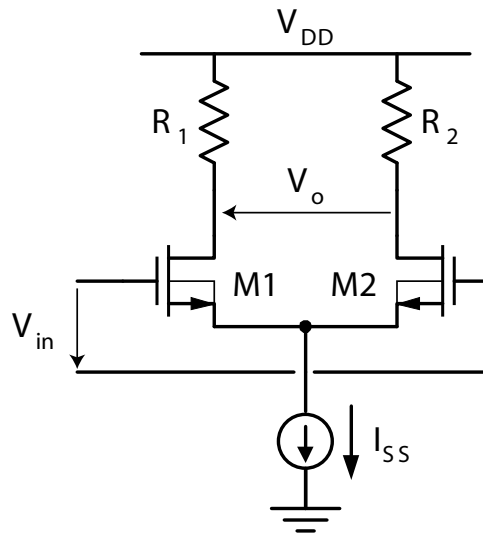## Problem Set 5
Due March 14, 2006

1. The offset voltage Vos of an amplifier is defined as the input required to satisfy $V_o = 0V$. Calculate the variance of the offset voltage of the differential amplifier below as a function of σ_{Vth}, $\sigma_{\frac{\Delta R}{R}}$, I_{SS}, and V^*. Use the square-law approximation (i.e. $V_{od} = V^*$) and assume infinite transistor output resistance.

2. For the amplifier schematic and its closed-loop configuration shown below, calculate your results as a function of the V^* of each transistor, I_{SS}, and C_s, C_f, C_i, C_L, C_{x1}, C_{x2}. Assume all transistors are in the forward active region and ignore the body effect. The bias is generated by a high-swing bias generator and set up to maximize the available signal current at the output without wasting current. Pairs of transistors are perfectly matched. For simplicity you may ignore all capacitors except those explicitly shown in the schematics.
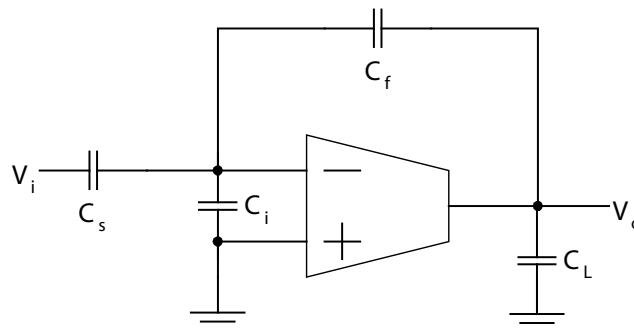
- Derive an expression for the spectral density of the low frequency input referred voltage noise for the open-loop amplifier at input V_{i1}. Ignore flicker noise.

- Explain why the amplifier has a systematic offset and propose a simple and practical circuit modification to reduce the systematic offset significantly.

- Derive an expression for the unity-gain bandwidth of the closed-loop amplifier. Assume that the amplifier has large phase margin.

- Derive an expression for the value of C_{x1}, C_{x2} that results in optimally fast linear settling.

- Derive an expression for the amplitude of the maximum step at the input of the closed-loop amplifier for which no slewing occurs. You may use the $||$ sign to indicate capacitors connected in series and define shorthand notation such as $C_T = C_s + C_f + C_i$ or $F = C_f/C_T$ to keep your equations simple.

- Derive an expression for the slewing portion of the settling time of the closed-loop amplifier as a function of the input step, $V_{i,step}$, and relative settling accuracy, ϵ . Ignore C_{x1}, C_{x2} and assume $V^* = V_{ov}$. You may use the $||$ sign to indicate capacitors connected in series and define shorthand notation as above.