EE539: Analog Integrated Circuit Design; HW4

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due on 7 Mar. 2007

0.18 μm technology parameters: $V_{Tn} = 0.5$ V; $V_{Tp} = 0.5$ V; $K_n = 300\ \mu\text{A}/V^2$; $K_p = 75\ \mu\text{A}/V^2$; $A_{VT} = 3.5\, mV\ \mu$m; $A_\beta = 1\%\, \mu$m; $V_{dd} = 1.8$ V; $L_{min} = 0.18\ \mu$m, $W_{min} = 0.24\ \mu$m; Ignore body effect unless mentioned otherwise. Ignore 1/f noise unless mentioned otherwise.

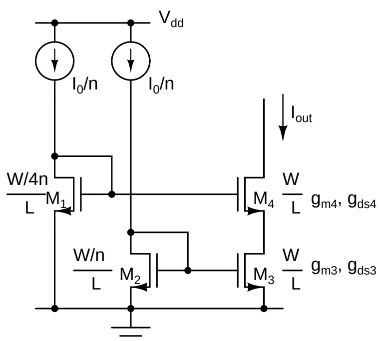

Figure 1: Problem 1

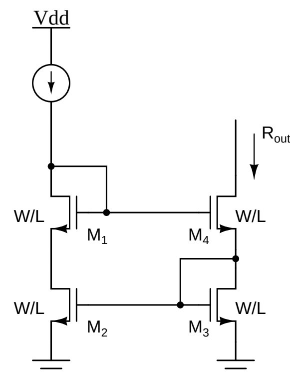

Figure 2: Problem 2

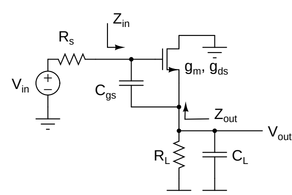

Figure 3: Problem 3

1. Determine the output current in Fig. 1. Determine the output noise current in terms of small signal parameters of M_3 and M_4. Which of the devices primarily contribute to the noise? Determine the output current error due to current factor and threshold mismatches ($\Delta\beta_{13}, \Delta V_{T13}$ between M_1 and M_3, and $\Delta\beta_{24}, \Delta V_{T24}$ between M_2 and M_4). Which of the mismatches is more critical?

2. Determine the output resistance of the current mirror in Fig. 2.

3. Determine the transfer function V_{out}/V_{in} input and output impedance of the source follower Fig. 3.

4. Design a cascode current sink (4) that provides 10 μA, 20 μA, and 40 μAoutputs from a 5 μAreference. The output voltage can be as low as 200 mV. Use 0.6 μmlength transistors. Report V_{DS}, V_{DSAT}, of all transistors and all node voltages.

   Plot the output current versus output voltage as the latter is varied from 0 to 1 V.

   Simulate the small signal output impedance (of

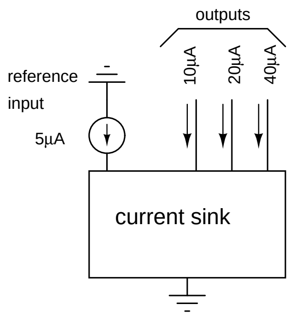

Figure 4: Problem 4

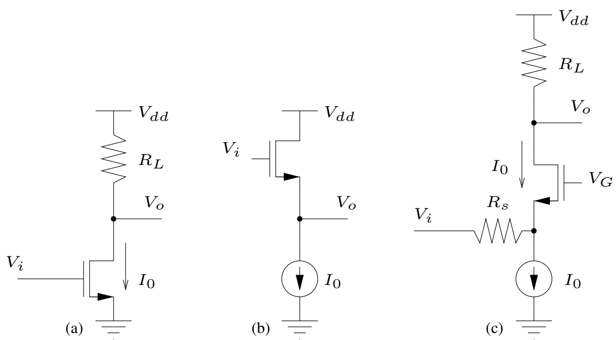

Figure 5:

the 80 μA output) from 1 kHz to 1 GHz with the output voltage fixed to 0.3 V. Reduce the width of the cascoding devices by a factor of 2 and resimulate the output impedance. (Overlay the impedance plots in the two cases).

Determine the threshold voltage mismatch σ_{VT} between the trnasistors in the reference and the 40 μA output branches. Connect dc voltage sources of value $3\sigma_{VT}$ between the gates of the reference and the output branches and simulate the output current error (fix the output at 0.3 V). Repeat this exercise for both channel lengths of the cascoding device. What are the contributions from the bottom and the top devices?

Don't submit the following problems, just try them out.

1. Determine the spectral density of output noise voltage and input referred noise voltage of the stages in Fig. 5.