AAIC Homework 3

Due Fri. Apr. 14, 2006

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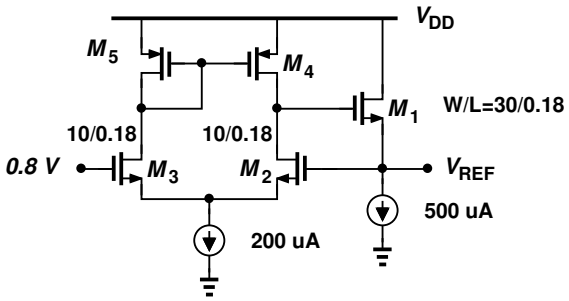
Please use the course SPICE device model for your simulation.

1. In this problem, we study the effect of a nonideal voltage reference upon the settling behavior of a 6-bit segmented DAC. The circuit is shown in Fig. 4.23 of the textbook. Assume each switch has a $W/L = 3\ \mu$ m/.18 μ m, each capacitor is 0.5 pF, and the supply voltage is 1.8 V. Instead of the reset switch, use the *.ic* command to set the initial condition to zero in HSPICE.

(a) If the reference voltage is ideal and equal to 0.8 V, what is the simulated settling time to 0.5 LSB in a 10-bit system?

(b) Suppose the reference is generated using the following circuit. Obtain the minimun M_4 size



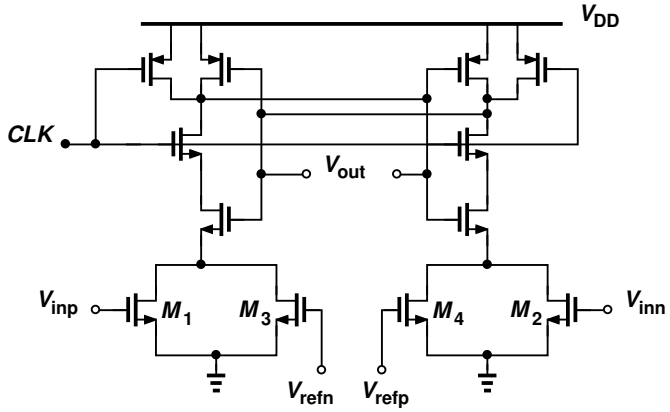
(Hint: M_4 has to be in saturation region) by simulation. What is the small-signal output impedance of the circuit? What would this suggest about the worst-case settling time of the above DAC if it uses this reference?

(c) Simulate the DAC with the above reference generator and measure the settling time. Explain the discrepancy between this result and the estimate in (b).

(d) Suppose V_{REF} is provided externally from an ideal source but with 3 nH of series inductance. What is the settling time in this case? Add a resistor in series with the inductor and see how much you can improve the settling?

2. Consider the dynamic comparator design shown as follows:

(a) If M_1–M_4 have the same sizes, derive the equivalent g_{ds} for M_1/M_2 pair and M_3/M_4 pair,



respectively. Assume V_{in} has common-mode voltage at V_{cm} and V_{rcm} and M_1–M_4 are in linear region when CLK is low. Identify the characteristics of the comparator and determine if we need to have the same V_{cm} and V_{rcm} to allow the circuit work properly.

(b) Now, let's change the ratio of $M_{1,2}$ to $M_{3,4}$ from 1 to 4. Please identify the characteristics of the comparator (V_{in} vs. V_{out}).

(c) Now, use HSPICE to perform the follow simulation to see the resolution of the comparators. In this part, you can set $V_{cm} = V_{rcm} = 0.9V$ and $V_{refp} - V_{refn} = 0.3V$. All dimensions of transistors are 5/0.18 except M_1 and M_2 are 20/0.18.

(d) If we change V_{cm} to 0.6 V, repeat (c) and find out the resolution of the comparators. Explain it if you see different results.