VLSI DATA CONVERSION CIRCUITS : PROBLEM SET 5

Problem 1

In this problem, we will figure out how to calculate (and plot) DNL and INL of an ADC from measured data. One way of doing this is to use a slow linear ramp to excite the ADC, and collect the output codes. Knowing the ramp slope, one can compute the normalized DNL and INL of the converter. The attached MATLAB data file called flash.mat, which consists of the input ramp voltage, and the corresponding digital output code (in decimal form) of a 6-bit flash ADC.

1. Find the LSB size and offset of the ADC.
2. Compute and plot the normalized DNL and INL of the ADC.
3. Include the MATLAB code you used to do the above in your report.

Problem 2

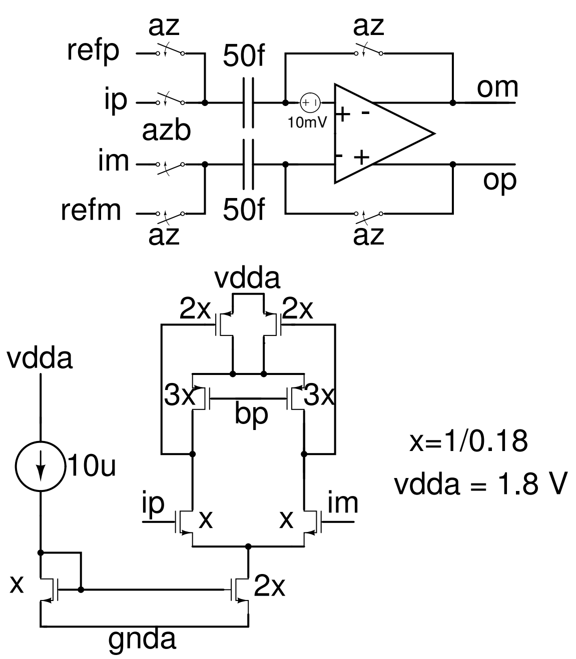

Figure 1: Circuits for Problem 2.

Fig. 1 shows a preamplifier to be used in a flash ADC. The circuit diagram of the preamp is shown in the lower part of the figure.

1. Design an appropriate circuit to generate the bias voltage *bp*.
2. What does the input common-mode voltage of the preamp settle to ?
3. In series with the input terminals of the preamp, insert a 10 mV voltage source as shown in the figure. Simulate the auto-zero action of the preamp - assume that the differential reference is 100 mV, with a common-mode voltage of 900 mV. Show, on the same picture, the waveforms at the input of the preamp during the auto-zero phase.

Problem 3

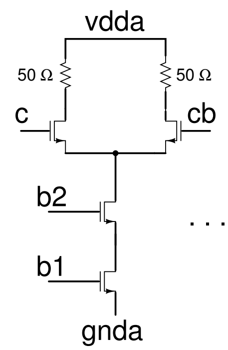

Figure 2: Current cell for Problem 3.

A 10-bit current steering DAC is to be designed. Assume 6-bit thermometer and 4-bit binary segmentation. The current cell architecture is shown in Fig. 2. The DAC output current is converted into a voltage by 50 Ohm resistors. The peak-to-peak differential output swing of the DAC is to be 1.024 V nominally. Assume A_{VT} for NMOS devices is 7 mVμ. The 3 σ INL of the DAC should be less than 0.5 LSB. The supply voltage is 1.8 V.

1. Determine the size of the "current-source" device in the thermometer current cell. Design a bias circuit to generate the bias voltages $b1$ and $b2$. Assume you have an ideal 16 μA current source from which to derive all bias voltages.
2. How will you choose the common-mode voltage of the switch control signals c and cb ? How about the amplitude of these signals ?
3. Generate (using ideal sources) appropriate drive signals using your results of part (2) above. Use rise/fall times of 100 ps. First, make the signals perfectly complementary, and plot the waveform at the source coupled node of the differential pair. Also plot the drain currents of both transistors. Next, skew the cb relative to c by +/- 100 ps and repeat the earlier exercise. What do you observe ?
4. Determine σ_I/I of the unit current source in the thermometer portion. Use this information to generate random current sources for the thermometer and binary portions of the DAC, and plot the DNL and INL of the DAC.