May 14, 2010, 3 - 3:50 pm

A 4-bit segmented DAC is shown below. The two MSBs control the switches which connect the two buffers to adjacent taps on the resistor string containing the resistors $R_m$. The LSBs select one of the tap voltages of the $R_i$ string as the output voltage. Assume $V_R = 5$ V, and buffer offset voltages $V_{OA} = 0.2$ V, $V_{OB} = 0.5$ V. All resistors are equal to 1 kilohm.

a. Find the equation for the output $V_{out}$ as a function of $m$ (the value of the MSB word), and of $l$ (the value of the LSB word).

b. Plot the input-output characteristics of the DAC.

c. What is the offset error? What is the gain error?

d. Find the INL and DNL. You may neglect the gain error in these calculations.
a. \( V_{out} = V_{m-1} + \frac{1}{4} (V_m' - V_{m-1}') = \frac{5}{4} m + \frac{1.55}{4} b + 0.2 \text{ (V)} \)

b. 

![Graph showing output voltage vs. input digital code]

- \( V_R = 5V \), \( M = 4 \), \( L = 4 \), \( V_{oa} = 0.2V \), \( V_{ob} = 0.5V \)

- At 5.1125V, \( \Delta \text{DNL} \)

- \( (15/16)5 = -0.225 \text{V} \)

- \( \text{DNL} = (\frac{5}{4} - \frac{1.55}{3} - \frac{5}{16}) = -0.225 \text{ V} = -0.72 \text{ LSB} \)

c. Offset error = 0.2 V, gain error = 5.1125 - 0.2 - 

d.\( \text{INL} = \frac{1.55}{4} - \frac{5}{2} - \frac{3}{16} = 0.225 \text{ V} \)