EE 247 Homework #4

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Problem #1:

$V_{in\_pp} := 100mV$ $\quad B := 14$ $\quad V_{FS\_pp} := 2V$

$\Delta := \frac{V_{FS\_pp}}{2^B}$ $\quad \Delta = 122.07\,\mu V$

$P_{QN} := \frac{\Delta^2}{12}$ $\quad P_{in} := \left(\frac{V_{in\_pp}}{2 \cdot \sqrt{2}}\right)^2$ $\quad P_{in} = 1.25 \times 10^{-3}\,V^2$ $\quad P_{QN} = 1.242 \times 10^{-3}\,mV^2$

$SNR := 10 \cdot \log\left(\frac{P_{in}}{P_{QN}}\right)$ $\quad SNR = 60.029\,dB$

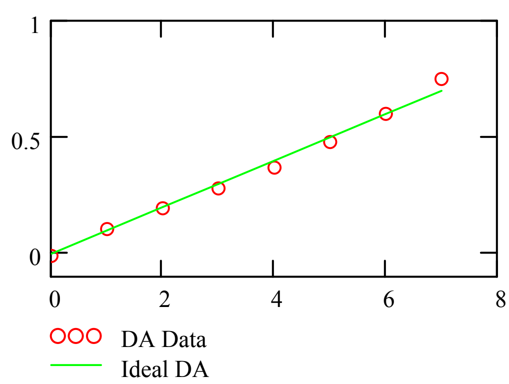
Problem #2:

$B := 3$ $\quad \Delta := 100mV$ $\quad W := 2^B$ $\quad W = 8$

$V_{out} := (-0.01V \;\; 0.105V \;\; 0.195V \;\; 0.28V \;\; 0.37V \;\; 0.48V \;\; 0.6V \;\; 0.75V)$ $\quad V_a := V_{out}{}^T$

$V_{ideal} :=$ | for $i \in 0..W-1$
  $x_i \leftarrow i \cdot \Delta$
  x

$i := 0..7$



$\varepsilon_{offset} := \frac{V_{a_0} - V_{ideal_0}}{\Delta}$ $\quad \varepsilon_{offset} = -0.1\,LSB$ $\quad \varepsilon_{FS} := \frac{V_{a_{W-1}} - V_{ideal_{W-1}}}{\Delta}$ $\quad \varepsilon_{FS} = 0.5\,LSB$

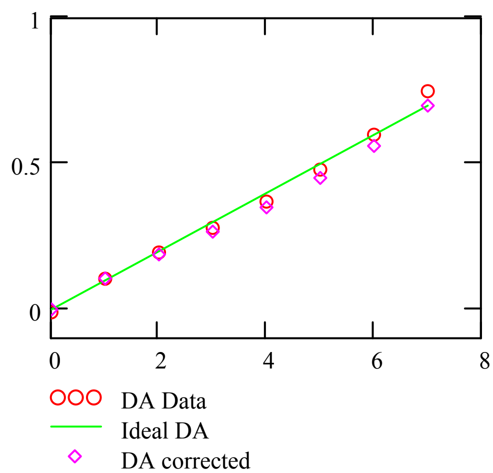
$$G_{actual} := \frac{Va_{W-1} - Va_0}{\Delta \cdot (W-1)} \qquad G_{actual} = 1.086 \frac{LSB}{code}$$

$$G_{ideal} := \frac{Videal_{W-1} - Videal_0}{\Delta \cdot (W-1)} \qquad G_{ideal} = 1 \frac{LSB}{code}$$

$$\varepsilon_{gain} := G_{actual} - G_{ideal} \qquad \varepsilon_{gain} = 0.086 \frac{LSB}{code}$$

$$V_{a\_corr} := \left| \begin{array}{l} \text{for } i \in 0..W-1 \\ \quad x_i \leftarrow \dfrac{V_{a_i} - \varepsilon_{offset} \cdot \Delta}{G_{actual}} \\ x \end{array} \right. \qquad V_{out\_corr} := V_{a\_corr}{}^T$$

$$V_{out\_corr} = (0 \quad 105.921 \quad 188.816 \quad 267.105 \quad 350 \quad 451.316 \quad 561.842 \quad 700)\,mV$$



$$DNL := \left| \begin{array}{l} \text{for } i \in 0..W-2 \\ \quad x_i \leftarrow \dfrac{V_{a\_corr_{i+1}} - V_{a\_corr_i} - \Delta}{\Delta} \\ x \end{array} \right. \qquad INL := \left| \begin{array}{l} \text{for } i \in 0..W-1 \\ \quad x_i \leftarrow \dfrac{V_{a\_corr_i} - V_{ideal_i}}{\Delta} \\ x \end{array} \right.$$

$$DNL^T = (0.059 \quad -0.171 \quad -0.217 \quad -0.171 \quad 0.013 \quad 0.105 \quad 0.382)\,LSB$$

$$INL^T = (0 \quad 0.059 \quad -0.112 \quad -0.329 \quad -0.5 \quad -0.487 \quad -0.382 \quad 0)\,LSB$$

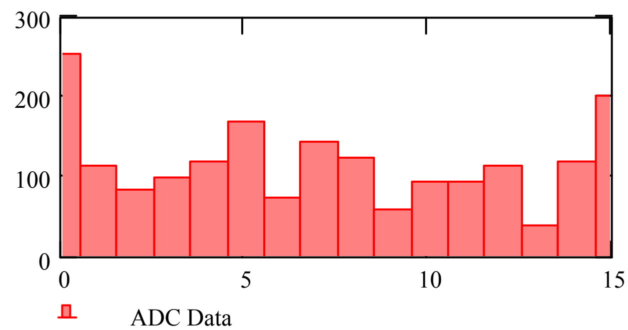
$\max(DNL) = 0.382\,LSB$ $\min(DNL) = -0.217\,LSB$ $\max(INL) = 0.059\,LSB$ $\min(INL) = -0.5\,LSB$

Part 3:

$B := 4$ $W := 2^B$ $W = 16$

$H_{ADC} := (253\ \ 115\ \ 85\ \ 100\ \ 120\ \ 170\ \ 75\ \ 145\ \ 125\ \ 60\ \ 95\ \ 95\ \ 115\ \ 40\ \ 120\ \ 202)^T$

$i := 0..15$



Removing the zero and full-scale bins and taking the average number of samples per bin:

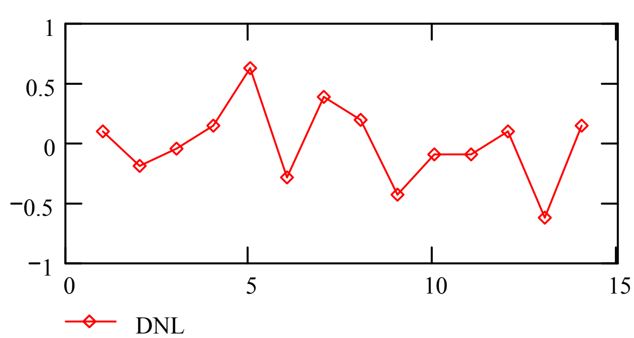
$$S_{ave} := \left| \begin{array}{l} x \leftarrow 0 \\ \text{for } i \in 1..W-2 \\ \quad x \leftarrow H_{ADC_i} + x \\ \dfrac{x}{W-2} \end{array} \right.$$

$S_{ave} = 104.286$

Normalize the given data to the average number of samples per bin:

$$N_{ADC} := \overrightarrow{\frac{\text{submatrix}(H_{ADC}, 1, 14, 0, 0)}{S_{ave}}}$$

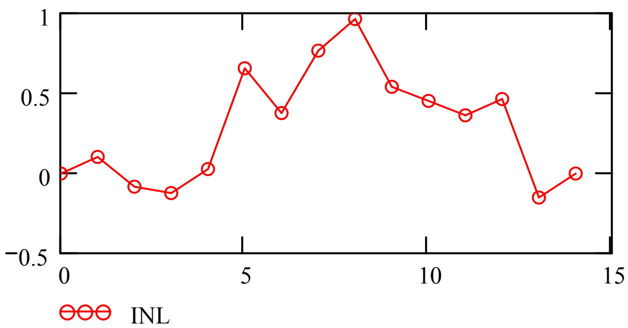
$$DNL := \overrightarrow{(N_{ADC} - 1)}$$



$\max(DNL) = 0.63\ LSB$

$\min(DNL) = -0.616\ LSB$

$$INL := \begin{vmatrix} x_0 \leftarrow 0 \\ \text{for } i \in 1..W-2 \\ \quad x_i \leftarrow x_{i-1} + DNL_{i-1} \\ x \end{vmatrix}$$



max(INL) = 0.966 LSB

min(INL) = −0.151 LSB

We cannot guarantee monotonicity since histogram testing assumes monotonicity.