HW4

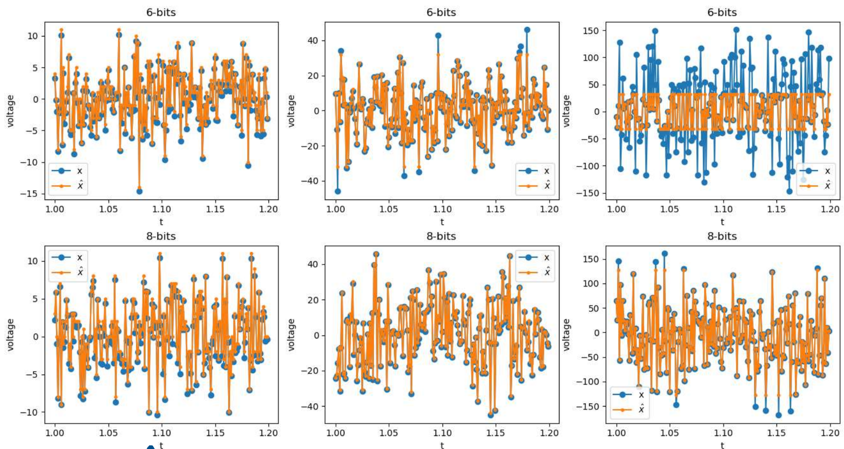
Thursday, February 16, 2023 8:56 AM

Q2 Simulate the effects of sampleling

- quantize with 6/8 bits.
- Input gaussian noise

$$RMS = \sqrt{\frac{\sum x_i^2}{n}}$$

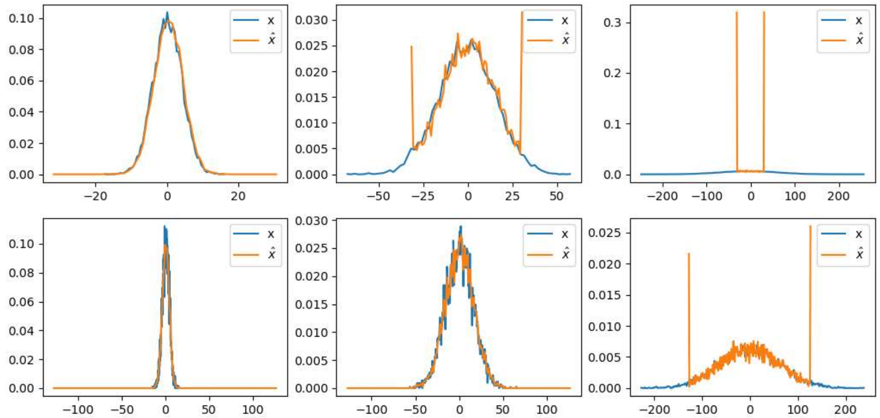
RMS to 2 bits → $2^2 = 4$ level



2bit rms 4bit 6 bit

Notes on selecting 6/8 bits.

- for the case 6 bit rms, 8 bit is needed. if 6 bit is chosen the signal is clipping as shown in the top right plot



← 6-bit ADC

← 8 bit ADC

Noise: ↑ 2 bits ↑ 4 bits 8 bits ↑

the shift of 0.5 is due to the convention the book use where if total no of bins are even they use m, $(m+1)$ as bins.

and $x \in [m, m+1)$

$\hat{x} = m + 1/2$

- For the original signal using auto bins to show the full histogram

Fixed this.

~~# Note on the clipping I see. its odd to see a high peak only at the minimum value.~~

Clipping persentage

	ADC bits 6	8
2	0	0
4	5	0
6	62.4	4.2

this is expectd

Correct Sampler

a. Not clear what this exactly means.
out of how many poits set to max and min or actually in that range

	ADC bits	
	6	8
2	—	—
4	14.76%	—
6	1.76%	3.67%

Some dont show clipping when the RMS is low compared to the total number of ADC bits used.

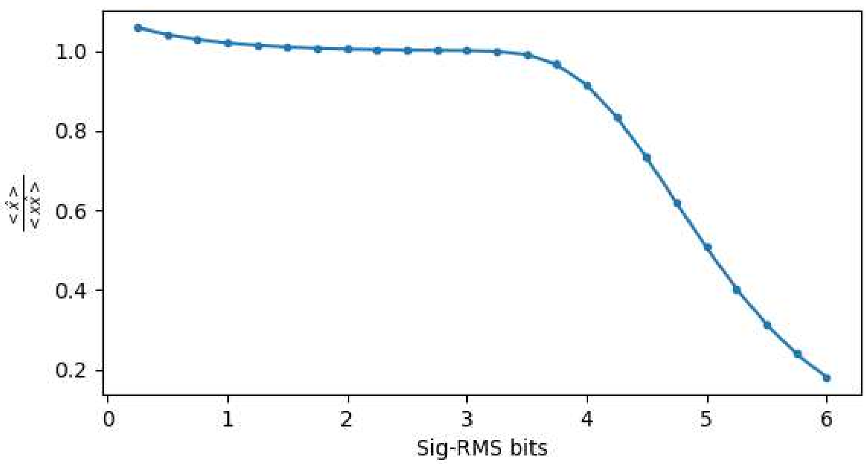
Variation of $\frac{\langle \hat{x} \rangle}{\langle x x' \rangle}$ → with rms of input signal.

bits $\frac{1}{4} = 2^{-2}$

$1/2 = 2^{-1}$

$1 = 2^{0} + 2^{-2}$ $\quad 1 + 1/4$

$2 = 2^{1}$



$\boxed{Q1}$ ADC Theory (using the book version)

assume 6 bits.

Increase of variance from.

2 bits → 5 bits.

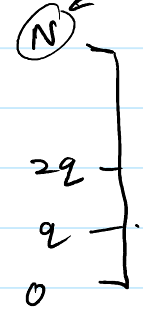
using the form given in the book for even number of level (N)

$$= \frac{2/\pi \left(1/2 + \sum_{m=1}^{N-1} e^{-m^2\epsilon^2/2} \right)^2}{(N-1/2) - 2\sum_{m=1}^{N-1} m \, \mathrm{erf}\left(\frac{m\epsilon}{\sqrt{2}}\right)}$$

n- bits.

no of levels

$N = 2^n$



ϵ - spacing between the levels.

from the formular we calculate

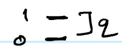
$$\frac{\langle \hat{x} \rangle}{\langle x\hat{x} \rangle} = \frac{(N-1/2)^2 - 2\sum_{n=1}^{N-1} n \, \mathrm{erf}\left(\frac{nq}{\sqrt{2}}\right)}{2/\pi \left(\sum_{n=1}^{N-1} e^{-n^2 q^2/2} + 1/2 \right)^2}$$

In the derivation we did we assumed the rms of the incomming signal will be one. and $q = 1$ (level spacing)

To modify the rms to given number of bits we need to strech that out.

$$\Rightarrow \quad q = 2^{Q} \qquad Q - \text{no of bits in the rms.}$$

In the derivation

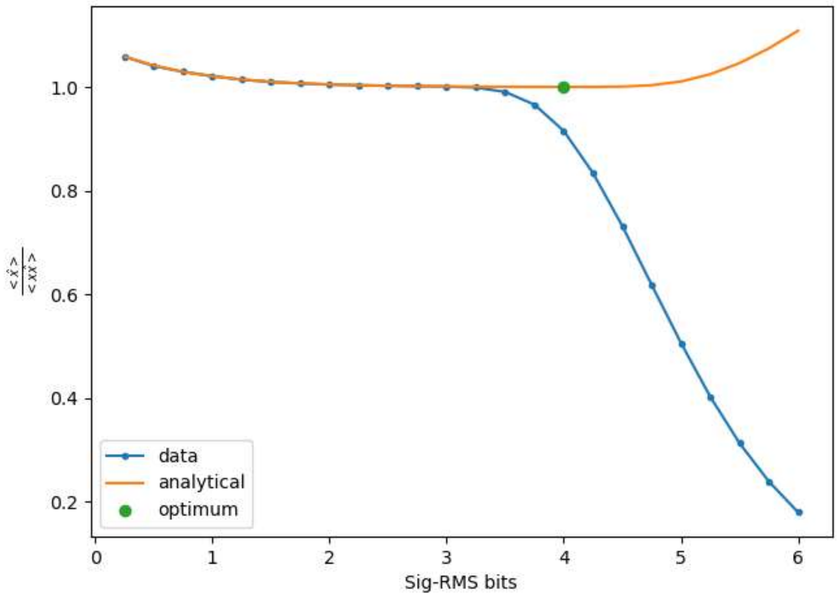


$$p(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \qquad \mu = 0, \ \sigma = 1$$

$$= \frac{1}{\sqrt{2\pi}} e^{-x^2/2}$$

to change the incomming signal now I can change q to match the scale

$$q = \frac{1}{2^{k-1}}$$



Code used for the activity: [Git/HW4]

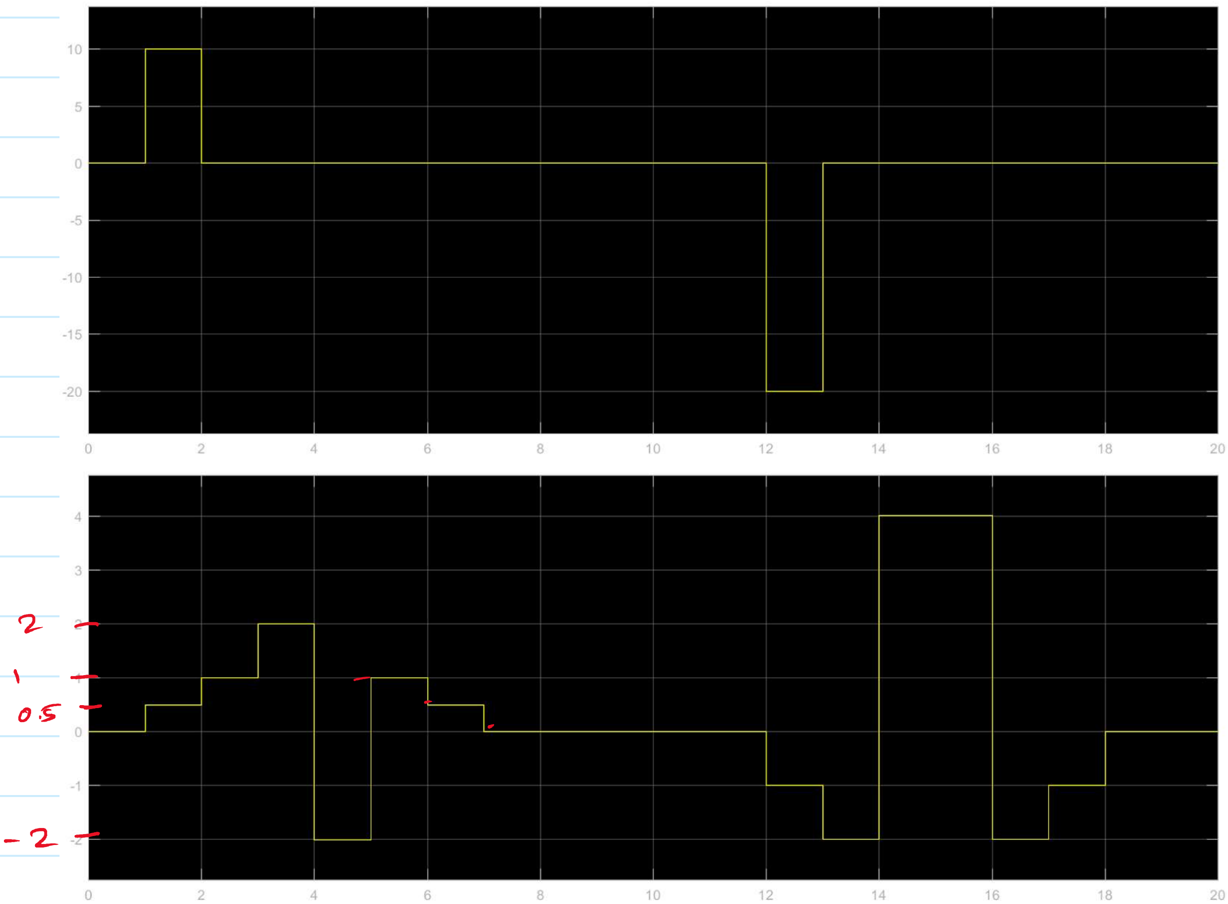
the simulated vs the calculated value matches well for up to 3 rms bits. as it increases beyond that it deviates. The likely reason for this is the assumption we made $x' = x - \alpha\hat{x}$ is not value.

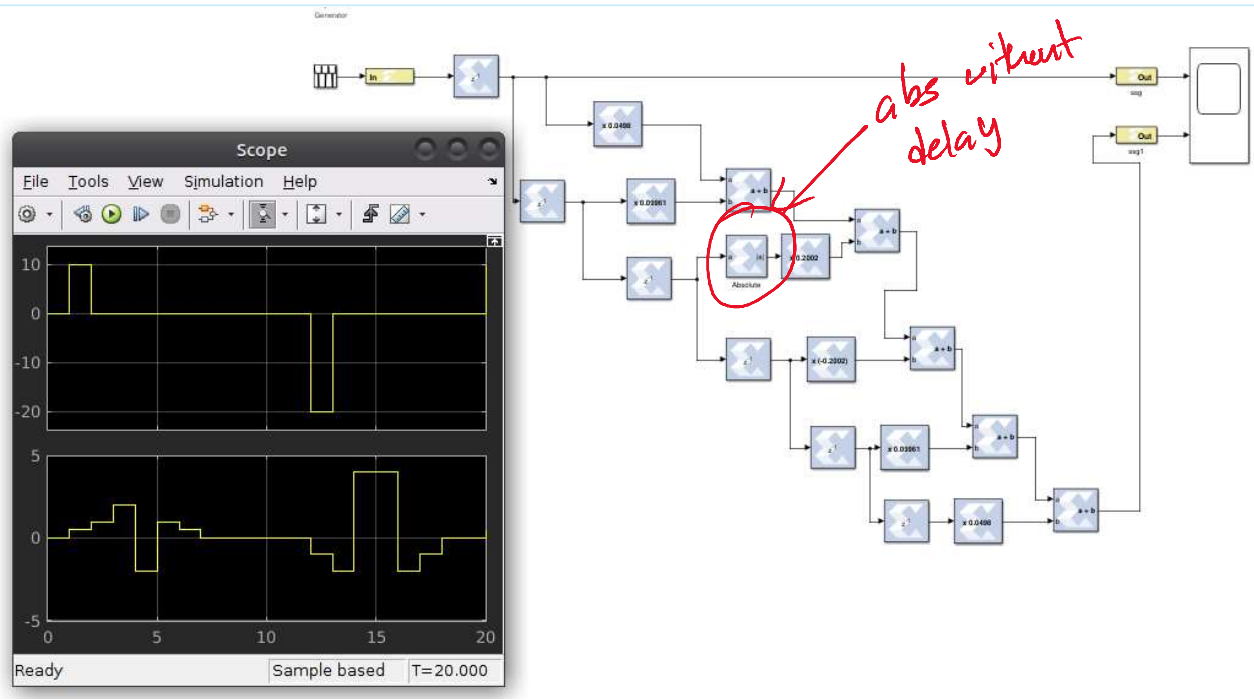
If you are using a sin() signal the optimal signal would be a signal with V_max = 6 bits. No clipping in such a case.

Q3

- Basic project given works well:

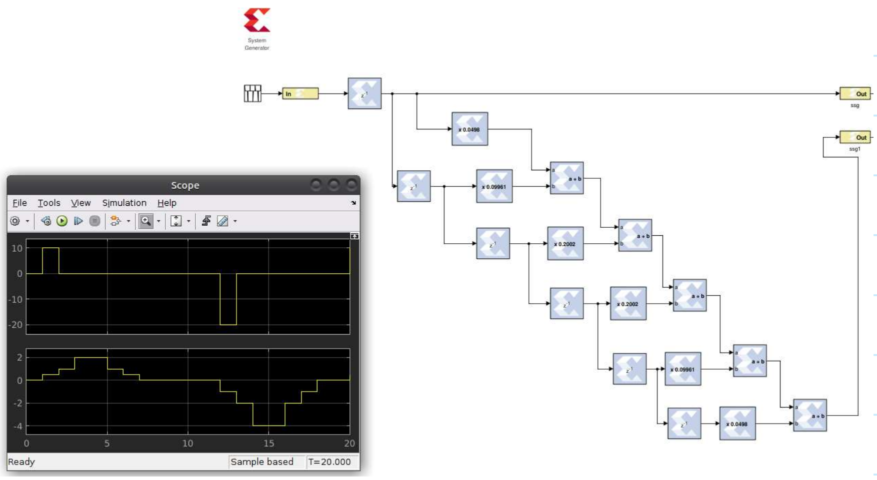
- figuring out the transformation. for the given question





Non linear responce.

##



System Generator
Scope
File Tools View Simulation Help
10
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-10
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0 5 10 15 20
Ready
Sample based
T=20.000
In
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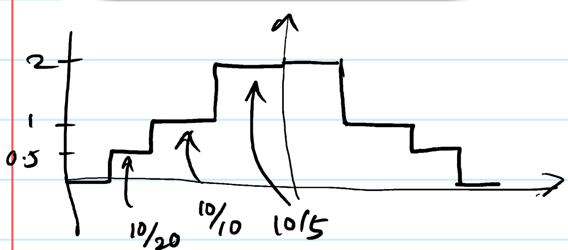
Out
a × b



2
1
0.5
10/20
10/10
10/5