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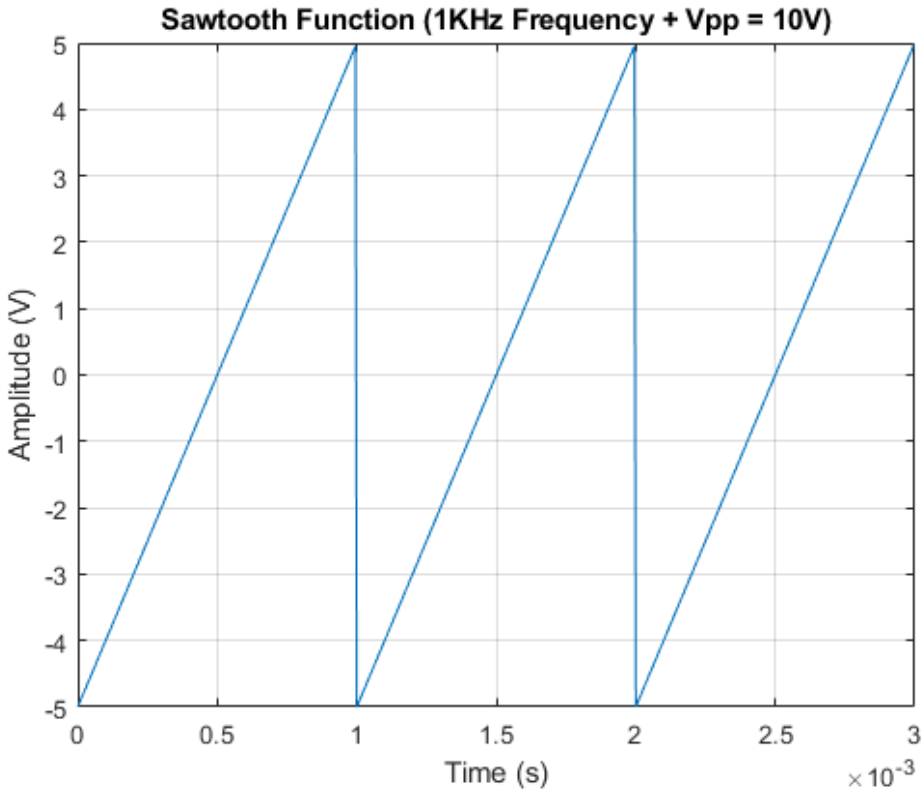
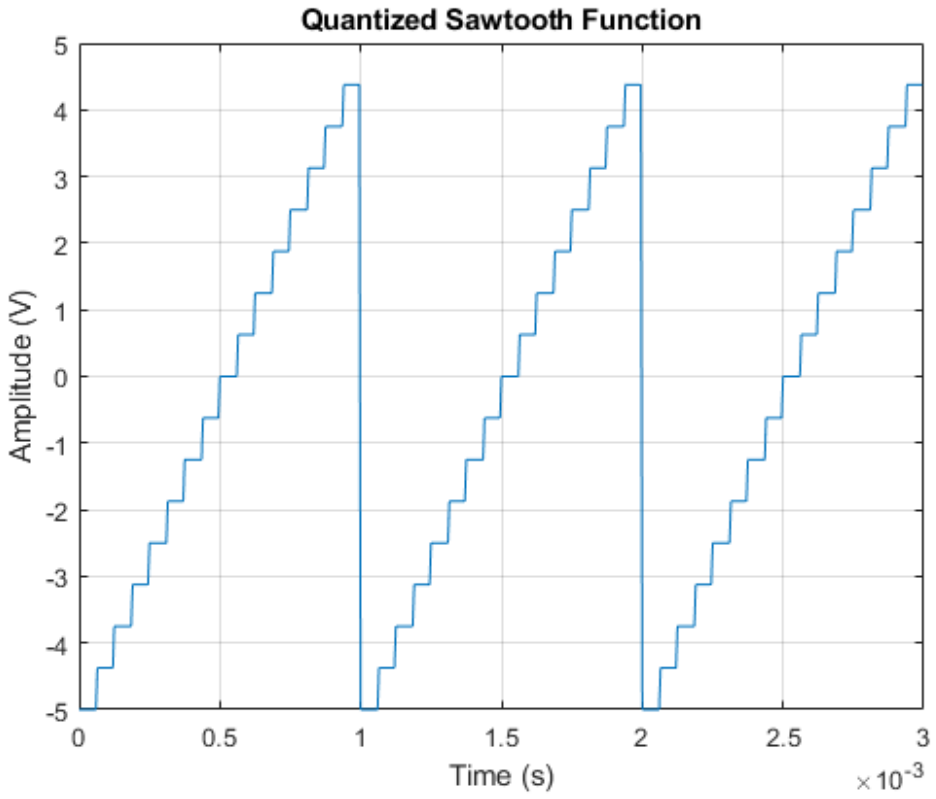
EECS 4214 – Digital Communications

Assignment 4 – Quantization

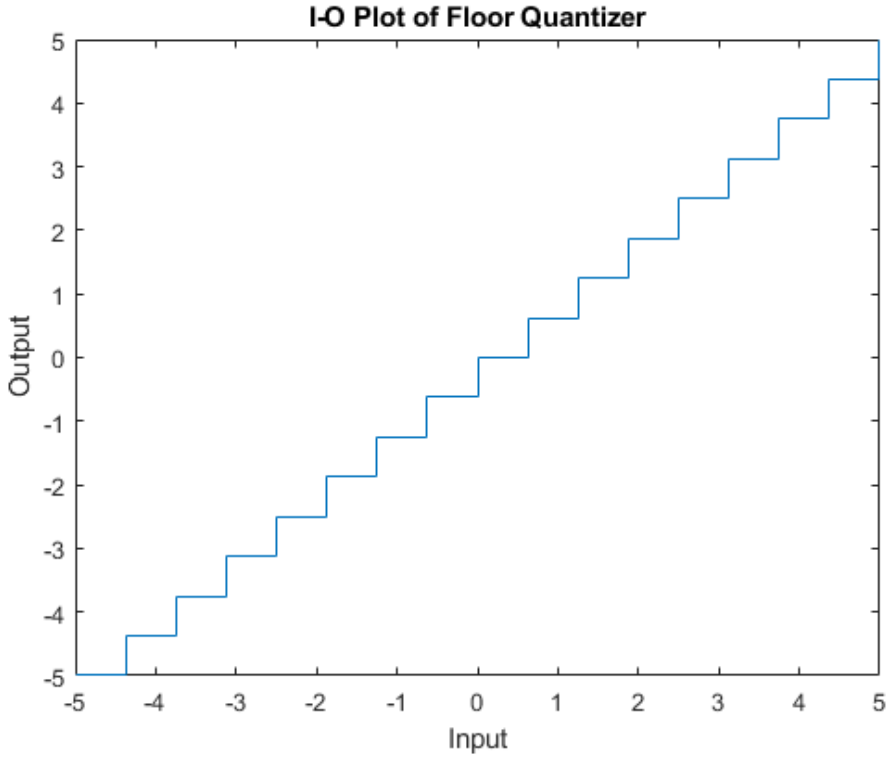
Friday, November 2nd, 2018

1.1

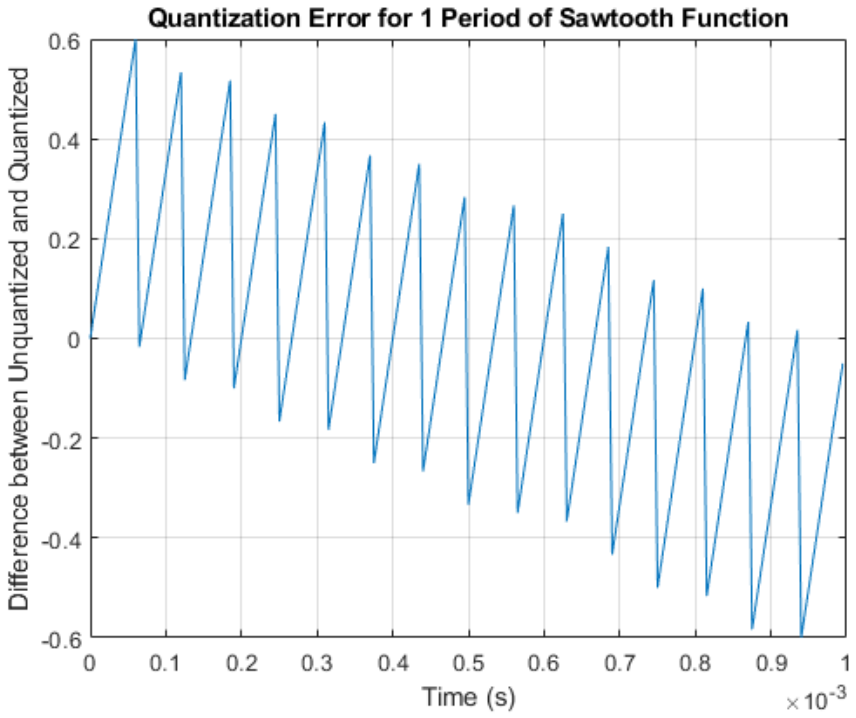

Sawtooth Function (1KHz Frequency + Vpp = 10V)
Amplitude (V)
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
0.5
1
1.5
2
2.5
3
Time (s)
×10^-3


Quantized Sawtooth Function
Amplitude (V)
Time (s)
×10^-3
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
0.5
1
1.5
2
2.5
3

1.2


I-O Plot of Floor Quantizer
Output
Input
5
4
3
2
1
0
-1
-2
-3
-4
-5

1.3

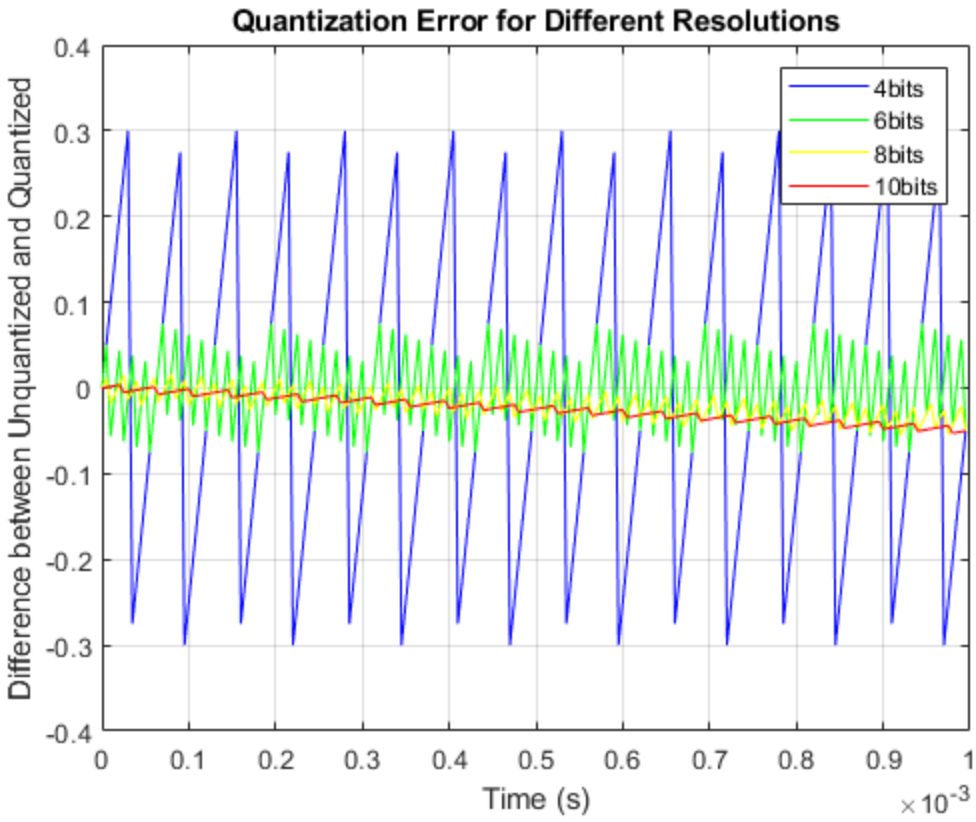


Using MATLAB's rms function I determined the rms value of the above waveform is 0.2626

1.4

Changing my quantizer from floor to round has improved the rms to 0.1803.

1.5



4bit rms = 0.1803

6bit rms = 0.0451

8bit rms = 0.0252

10bit rms = 0.00284

1.6 a)

Q = Vpp / L, where Vpp = Peak to Peak Voltage, and L = # of Quantization Levels

Resolution = 4bits, q = 10V / (2^4) = 10V / 16 = 0.625

E = $q^2/12$ = 0.0326

Resolution = 6bits, q = 10V / (2^6) = 10V / 64 = 0.15625

E = $q^2/12$ = 0.002

Resolution = 8bits, q = 10V / (2^8) = 10V / 256 = 0.0391

E = $q^2/12$ = 0.00013

Resolution = 10bits, q = 10V / (2^10) = 10V / 1024 = 0.00977

$E = q^2/12 = 0.000008$

b) In part 1.5, I found the rms values, so squaring those values

4bit = 0.0325

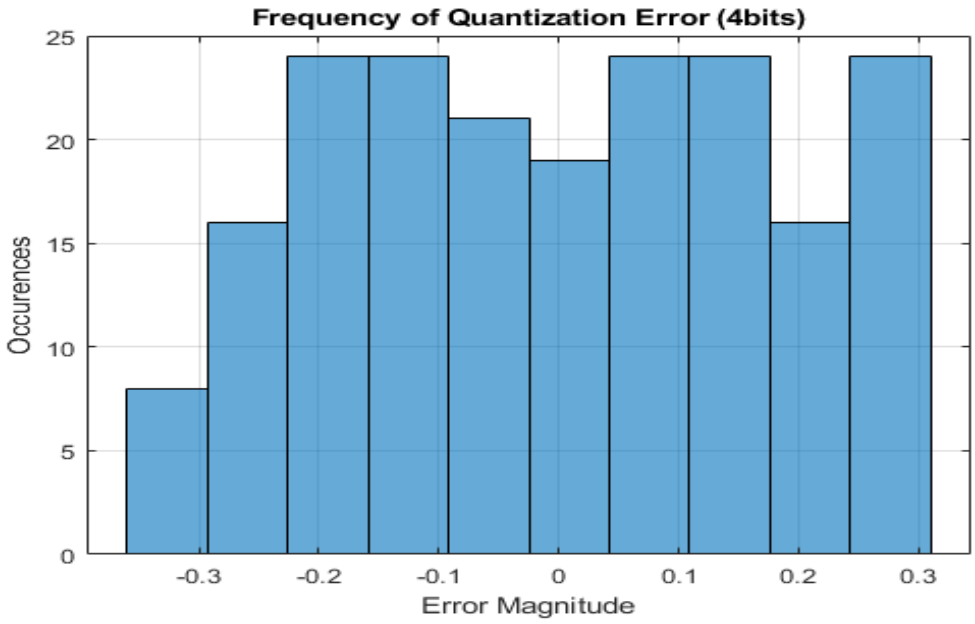
6bit = 0.00203

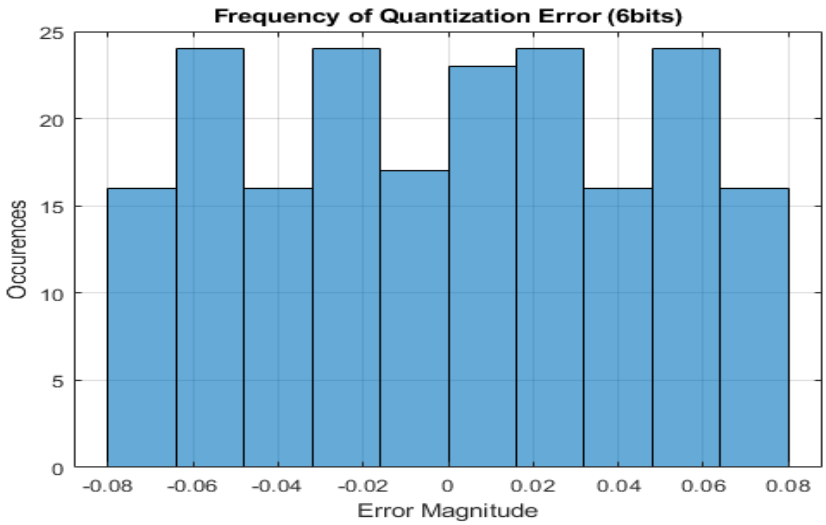
8bit = 0.000635

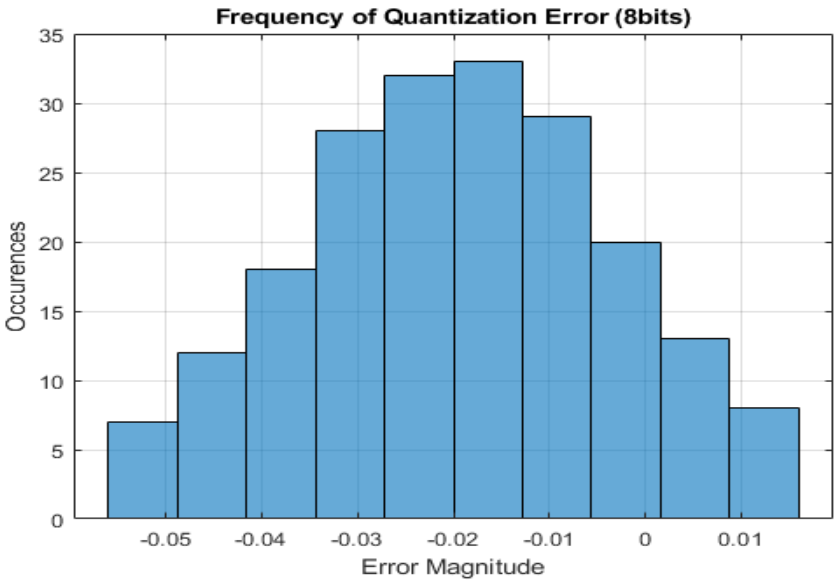
10bit = 0.00000807

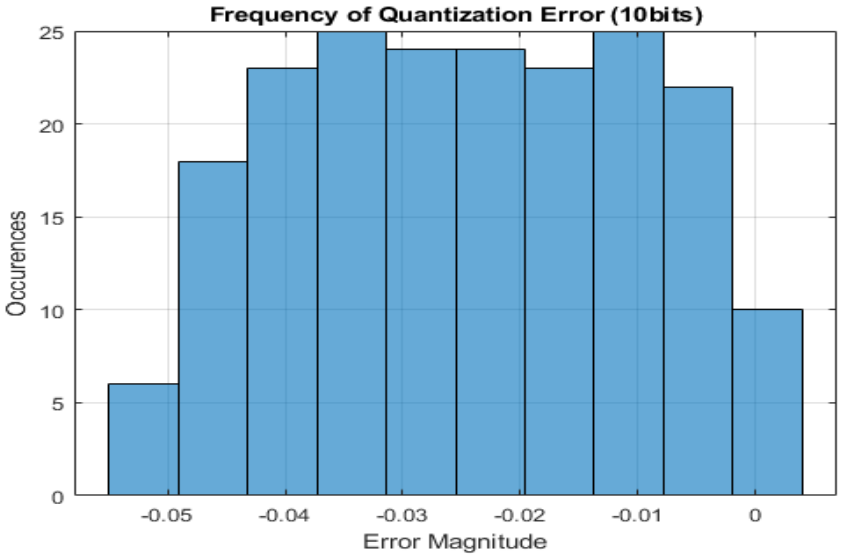
The results that I ended up with are very close to the by-hand calculations. The only value with significant difference is the 8bit value. I am not sure why this has occurred, but I am sure it is not an oversight in the MATLAB code itself, so it must be related to the design of my quantizer. It is possible that I made a miscalculation.

1.7

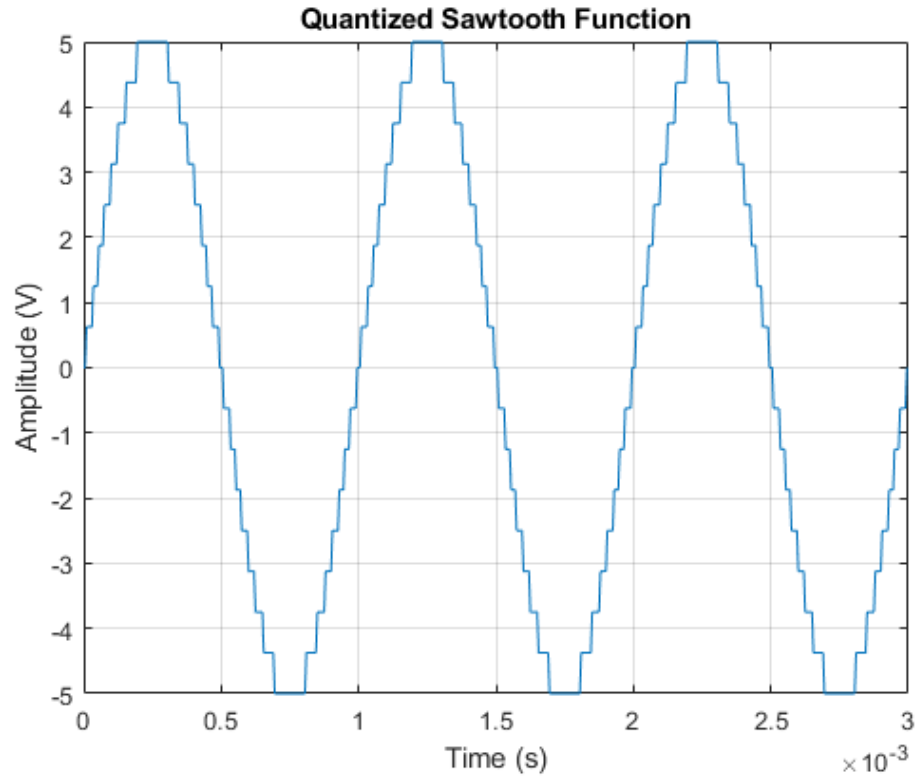


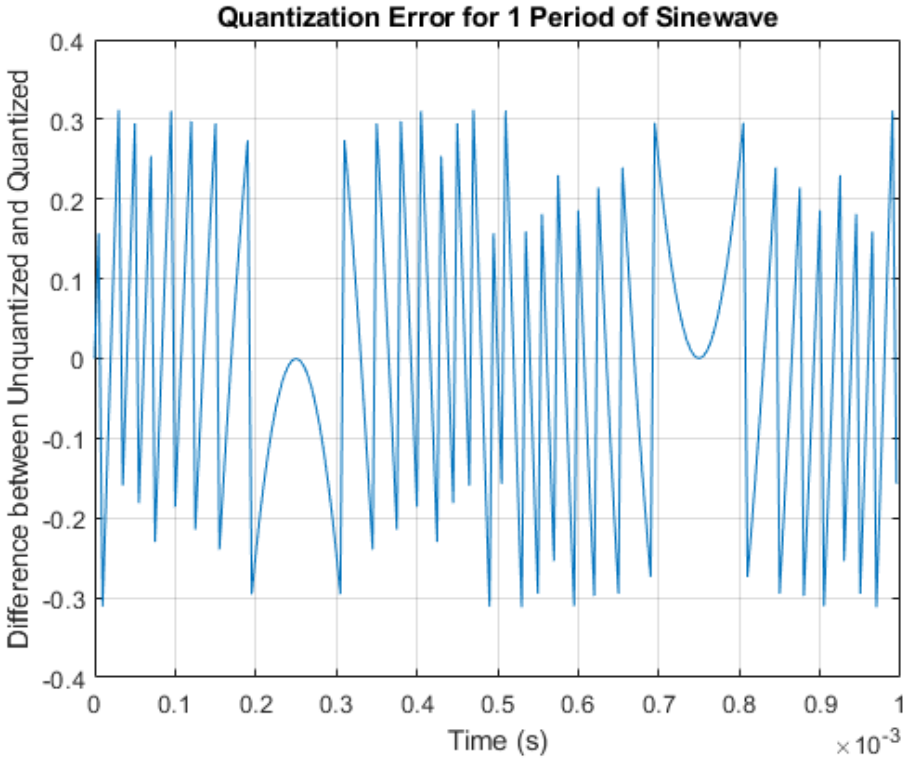

Frequency of Quantization Error (6bits)
Occurences
Error Magnitude
25
20
15
10
5
0
-0.08
-0.06
-0.04
-0.02
0
0.02
0.04
0.06
0.08


Frequency of Quantization Error (8bits)
Occurences
Error Magnitude
35
30
25
20
15
10
5
0
-0.05
-0.04
-0.03
-0.02
-0.01
0
0.01

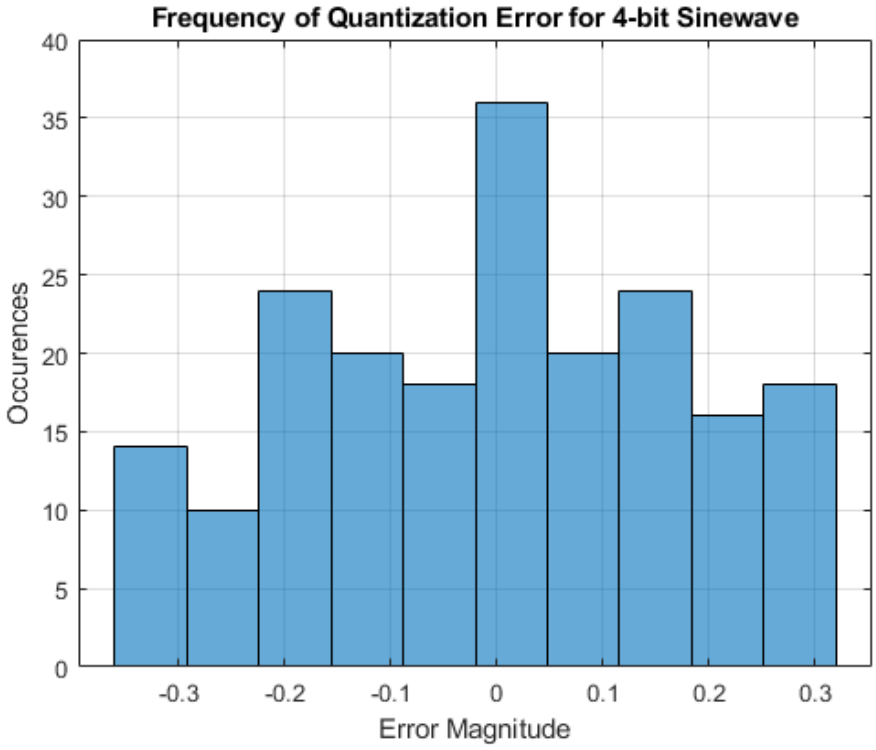

Frequency of Quantization Error (10bits)
Occurences
Error Magnitude
25
20
15
10
5
0
-0.05
-0.04
-0.03
-0.02
-0.01
0

2.1

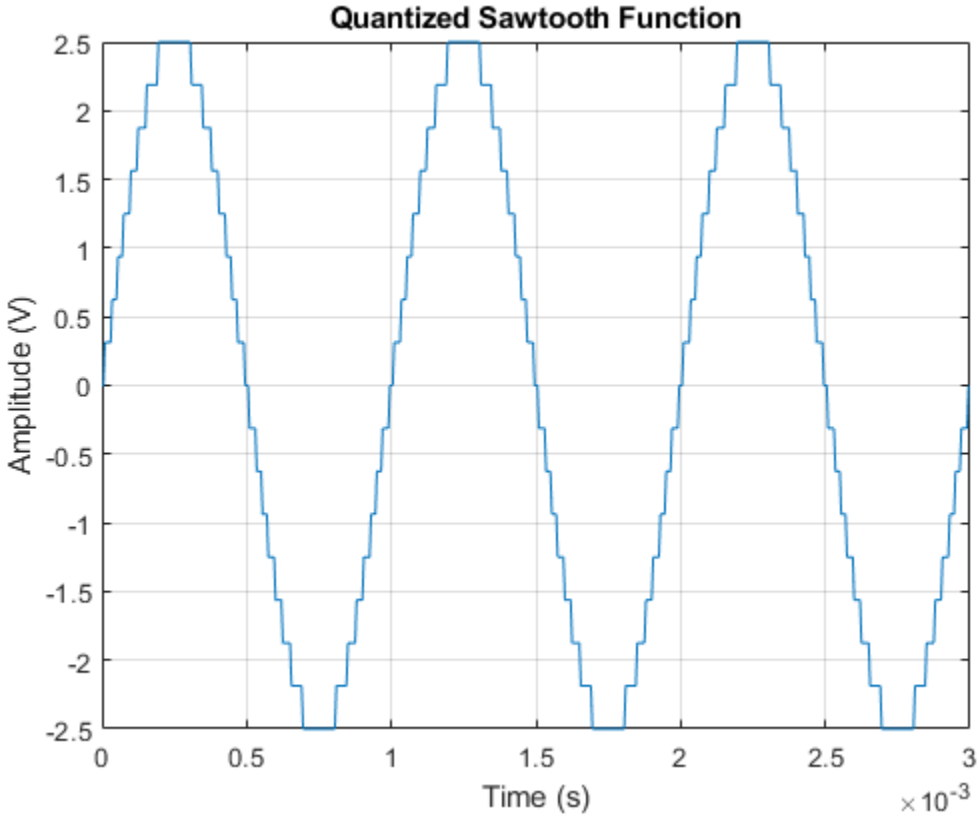


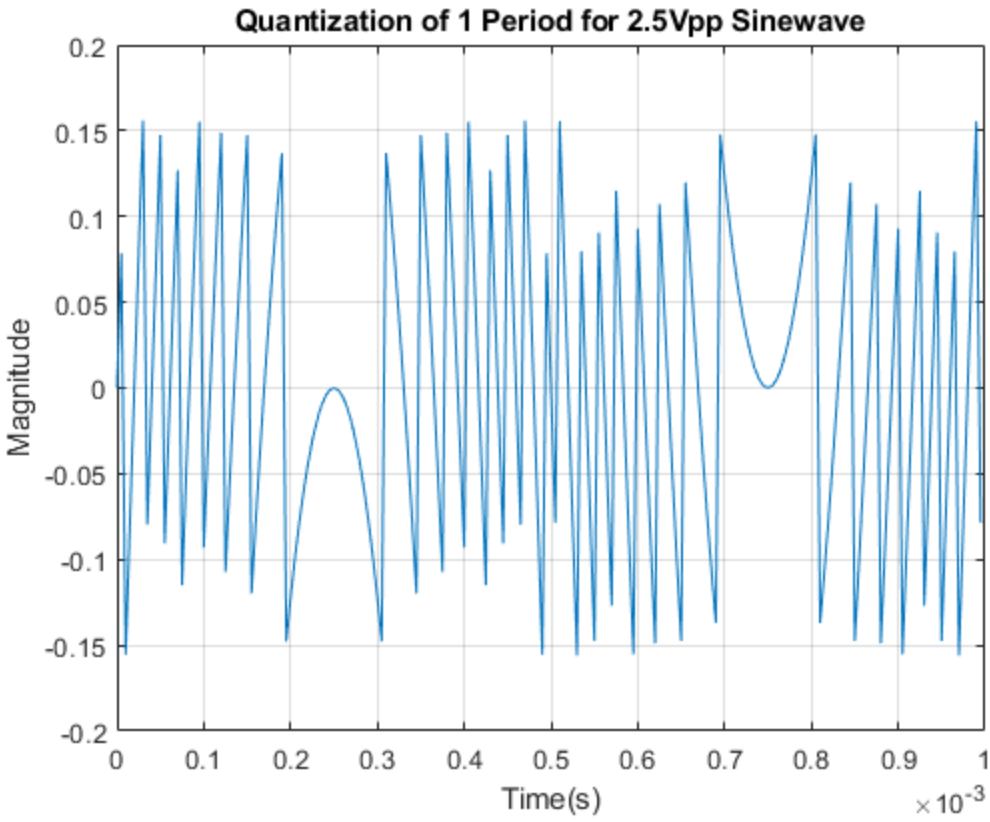


Using MATLAB's rms function I determined the rms value of the above waveform is 0.1753

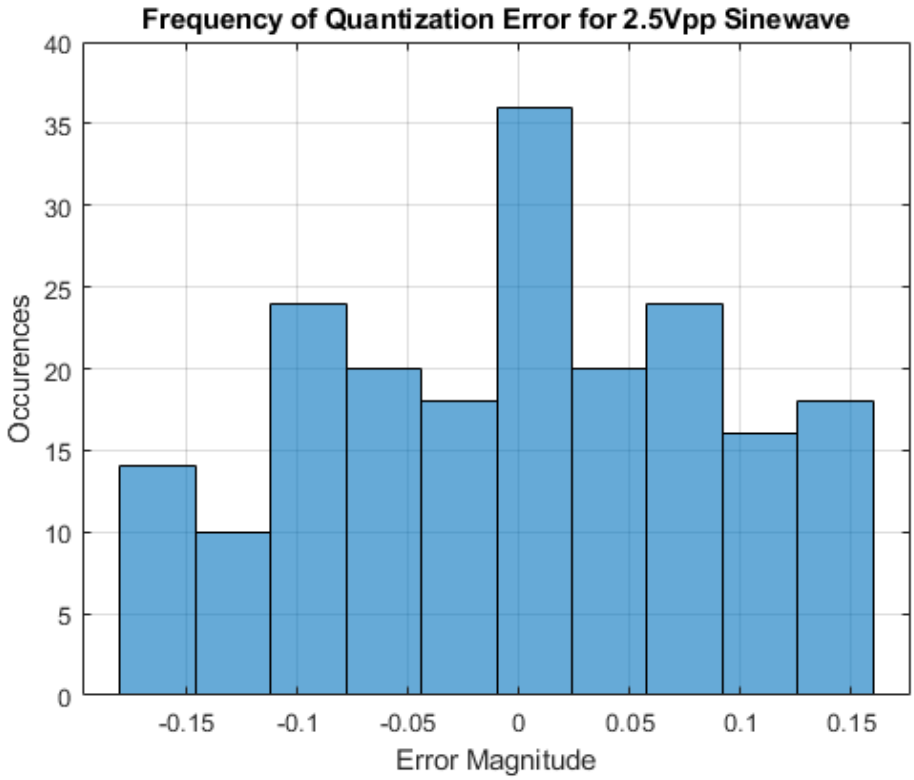

Frequency of Quantization Error for 4-bit Sinewave
Occurences
Error Magnitude
40
35
30
25
20
15
10
5
0
-0.3
-0.2
-0.1
0
0.1
0.2
0.3

2.2


Quantized Sawtooth Function
Amplitude (V)
Time (s)
×10^-3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
0
0.5
1
1.5
2
2.5
3



Using MATLAB's rms function I determined the rms value of the above waveform is 0.0877



Average quantization noise power = q^2 / 12

q = V / L

q1 = 10V / 2^4 = 10 / 16 = 0.625

AQNP1 = 0.625^2 / 12 = **0.0326**

q2 = 5V / 2^4 = 5 / 16 = 0.3125

AQNP2 = 0.3125^2 /12 = **0.00814**

Naturally reducing the peak to peak voltage results in smaller average noise power, since the signal is smaller, the noise which is proportional to it is also smaller. This is other way to impact the average power, given that we showed how increasing the sample rate can reduce it as well.