ECEN610:Mixed-Signal Interfaces

LAB 2: Signal to Noise Ratio, Quantization

1. SIGNAL TO NOISE RATIO (40%)

Generate a tone with frequency 2 MHz and amplitude 1 V. Sample the tone at frequencies Fs = 5 MHz.

a) Add Gaussian noise to the sampled sinewave such that the signal SNR is 50 dB. Find first the variance of the Gaussian noise needed to produce the target SNR. Calculate and plot the Power Spectral Density (PSD) from the DFT of the noisy samples. Corroborate that the SNR calculation from the DFT plot gives the theoretical result. What would be the variance of a uniformly distributed noise to obtain the same SNR.

b) Now repeat a.) using a window before the DFT. Use the following windows: Hanning, Hamming, Blackman. What are your conclusions?
NOTE: The use of windows mentioned above spreads the signal power. You must take this into account when computing SNR.

2. QUANTIZATION (60%)

a) Create a perfect quantizer with 6 bits of resolution and with flexible sampling rate. For a 200 MHz full scale input tone, sample and quantize the sinewave at 400 MHz and plot the PSD of 30 periods. What is the SNR? Repeat the SNR calculation for 100 periods of the same signal. Make your own conclusions about this test regarding periodicity of quantization noise and the impact of this in the SNR. How can you solve this problem?

b) Find an incommensurate sampling frequency larger than Nyquist rate. Plot the PSD of the new samples. Calculate the SNR from the figure.

c) Repeat a) using a 12 bit quantizer. Can you prove from simulations that SNR ~ 6N (where N is the number of bits used by the quantizer) in both the cases, N = 6 and N = 12?

d) Use a Hanning window and repeat c). What is the SNR? Make your own conclusions.

e) Now add noise again so the signal SNR is 38 dB . Repeat c) and d). What are the SNRs? Provide conclusions.

HINT: Write a python function using the numpy.round to perform Quantization on your waveform.