ECE 4429a – Advanced Digital Signal Processing
Fall 2020
Sampling & Quantization MATLAB experiments
September 30, 2020

NOTES:

1. Lab reports must be submitted individually before the deadline: **Oct. 7, 2020, 6:30 pm**. **Lab reports must be uploaded to OWL. Email submissions will not be accepted.**
2. Create a folder labeled “Lab1” on your Drop Box space in the course OWL site and upload your report and associated code to that directory.
3. Create a Word document that contains MATLAB figures, results, and your comments for each problem. Upload this document to the Lab1 folder.
4. Check the volume control before playing the signals through the headphones!

Sampling Experiments

1. (4 marks) Write a MATLAB script to generate 3-second sampled versions of the analog signal, $x(t) = 0.5\sin(5000\,\pi\,t)$, when the sampling rate is (a) 8000 Hz, and (b) 3000 Hz. Properly name this script file and upload it to the Lab1 folder. Use the “sound” command in MATLAB to play these sampled versions and comment on the difference. Explain this difference using the sampling theorem.

2. (6 marks) Download the file “ECE4429_Sampling1.m” from the “Resources -> Labs -> -> Lab1” folder. Go through this file and add comments to each line indicating its function. Upload the commented file to the Lab1 folder.

   What happens when you run this MATLAB script? Include in your report sample spectrograms when the sinusoidal frequency is 1000 Hz, 4000 Hz, and 7000 Hz. Discuss these results within the context of sampling theorem.

Quantization Experiments

1. (5 marks) Write a MATLAB function to return a quantized signal, *yq*, the quantization error, *eq*, and the signal-to-quantization noise ratio (SNR in dB). The inputs to this function are the discrete-time analog signal, *y*, the full-scale range of the quantizer, [*xmax* and *xmin*], and the number of bits, *m*. Upload this file to the Lab1 folder.

2. (5 marks) Use the above function to quantize an analog sinusoid $y(t) = 5\sin(200\pi t)$, when the full-scale range is [10 -10], number of bits is 6, and the sample rate is 8000 Hz. Let the duration of the sinusoid be 0.02 seconds.

   a. Include a plot of the original and quantized sinusoids.
   b. Report the theoretical and measured SNRs for this example.

Bonus Sampling Question

1. (5 marks) The following MATLAB experiment demonstrates aliasing with a chirp signal. A chirp is a signal whose frequency varies as a function of time. In the analog domain, the equation for generating a linear chirp signal is

$$x(t) = A\cos(\pi\mu t^2 + 2\pi f_1 t)$$

   where μ is the sweep rate in Hz/sec and f_1 is the starting frequency in Hz.

   - Write the discrete-time equivalent of the above equation when sampled at a frequency, f_s.
   - With f_1 = 100 Hz, μ = 2000, A =0.25, and f_s = 48 kHz, generate 8 seconds of sampled chirp signal. Use the "spectrogram" command (see #2 in *Sampling Experiments* section) to display the time-frequency structure of the sampled chirp signal. Include this spectrogram in your report, along with your comments on what you see. Play the sampled chirp signal using the "sound" command and describe what you heard.
   - Repeat the above step but this time using a sampling frequency of 16 kHz. Provide an explanation based on the sampling theorem as to why the sampled chirp sounds different and its spectrogram looks different with f_s = 16 kHz.