EE 435
Assignment 8
Spring 2025
Due Friday April 18

For Problems 3 and 4, you will be expected to email your Matlab code (the .m file) to the TA as a part of the HW assignment. They may choose to verify the performance so put sufficient comments in the code so that they can use it to characterize an arbitrary signal that includes a fundamental and an arbitrary harmonic of arbitrary magnitude and arbitrary phase.

Problem 1 If a 1024 point DFT is used to characterize the output of a good 10-bit ADC and if a near full-scale sinusoid is applied at the input, what is the approximate size of the DFT coefficients at frequencies other than the fundamental or harmonics? Assume coherent sampling is used and the number of periods is 17.

Problem 2 Consider a good 12-bit ADC that has a V_{REF} of 5Vand no device noise present.

a) What is the SNR if an input of 2+2sinωt is applied?
b) What is the SNR if an input of 2+0.1sinωt is applied?
c) What is the ENOB of the ADC if the input is always restricted to the range [1.9 2.1]?

Problem 3 Consider an audio system designed to provide 100W of output to a speaker that is driven with a 12-bit DAC. Assume the "speaker" is actually comprised of four 4Ω speakers connected in parallel. Assume the DAC provides a bi-directional output with reference voltages of $V_{REF}/2$ and $-V_{REF}/2$ (instead of 0 and V_{REF}).

a) What will be the RMS value of the voltage driving the speaker at the specified 100W power level?
b) If this system is used with the actual output level of 500mW to the speaker, what is the ENOB
c) What is the quantization noise (in watts) if the output signal is a 1KHz sinusoidal signal with a power level of 500mW.
d) Repeat part c) if the power level is 2W.

Problem 4 Consider an ideal 12-bit ADC that has a V_{REF} of 5V. Assume no device noise is present.

d) What is the SNR if an input of 2.25 +2sinωt is applied?
e) What is the SNR if an input of 2.25+0.1sinωt is applied?
f) What is the ENOB (relative to quantization noise) of the ADC if the input is always restricted to the range [1.9 2.1]?

Problem 5 Develop a MATLAB program for spectral characterization of a continuous-time signal (that might come from an infinite-resolution ADC). Assume the signal is sampled with a clock of period T_S and that the number of samples in N_{SAMP}. The program should find the THD and the SFDR of the signal assuming that any harmonics of the fundamental are due to distortion. In what follows, test the program with an input signal of Xin=sin(wt) + 0.1sin(3wt)

a) Demonstrate this program by using a 1024 point transform with exactly 31 periods of excitation to obtain the spectral response of the specified excitation.

b) Repeat part a) if there are 31.1 periods, 31.01 periods and 31.001 periods

c) Window the data from parts a) and b) using a Blackman Window (or Hamming if Blackman is not available) and compare the spectral components (add the two most adjacent terms in the appropriate way to get the value at each harmonic)

Problem 6 Develop a MATLAB program for spectral characterization of an n-bit DAC. The program should have a variables that can be set for an arbitrary number of bits of resolution, length of the DFT, and sampling rate for the DAC output.

Use this program to determine the quantization noise in an ideal 10-bit DAC if the output of the DAC is passed to a zero-order sample and hold. Assume the input is a full-scale sinusoid.

Use the program to determine the THD, SFDR and SNR for the output of an 12-bit DAC that has as an input the ideal 12-bit quantization of the signal $2\sin(100t) + 0.2\sin(200t) + 2V$. Assume $V_{REF}=5V$.