For Problem 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. For Problem 5 you will also be expected to email your Matlab code to the TA.

**Problem 1**

a) Prove the following theorem.

Theorem: If the INL of a DAC is less than ½ LSB, then the DAC is monotone.

b) The theorem of part a) was sufficient but not necessary. Give an example of a DAC that is monotone but has an INL that is greater than ½ LSB.

**Problem 2**

If a 1024 point DFT is used to characterize the output of a 10-bit ADC and if a full-scale sinusoid is applied, what is the approximate size of the DFT coefficients at frequencies other than the fundamental?

**Problem 3**

If a 12-bit ADC has a VREF of 5V, what is the SNR if an input of 2+0.1sin(ωt) is applied? What is the ENOB of the ADC if this input is applied?

**Problem 4**

Develop a MATLAB program for spectral characterization of a signal that might come from a data converter. 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 the input $X_i = \sin(wt) + 0.1\sin(3wt)$

a) Demonstrate this program by using a 1024 point transform with exactly 31 periods of excitation to obtain the spectral response of the 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 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 5**

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.

a) 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.
b) Use the program to determine the THD, SFDR and SNR for the output of an n-bit DAC that will be posted on the class WEB site by Wednesday.