Homework Assignment V

Reading Assignment: Kuc Chapter 3 and White-Doering Chapter 32

1. Suppose that we would like to sample the following function

\[ x(t) = 5 \cos(1000\pi t) + 2 \cos(3000\pi t + 137) + \sin[5000\pi(t - 1)]. \]

Find the sampling rates such that aliasing is guaranteed to be avoided.

2. Consider the following sampling scheme of the pure sinusoid \( x(t) = \cos(2\pi f t) \): sampling points are placed at all positive peaks, negative peaks, and all zero-crossings.

   (a) What is the sampling rate in this case?
   (b) How far apart in time are the samples in this case?

3. Consider a uniform quantizer/inverse quantizer as follows where

\[ y = \text{round} \left( \frac{x}{4} \right) \quad \text{and} \quad \hat{x} = 4y. \]

   (a) Sketch the mapping relationships between \( x, y, \) and \( \hat{x} \). Label carefully the quantization levels, the decision boundaries, and the reconstructed values.
   (b) Sketch the quantization error \( q = \hat{x} - x \) as a function of \( x \).
   (c) What is the power of the quantization noise \( (\sigma_q^2) \) in this case?
   (d) If the forward quantizer is now \( y = \text{floor} \left( \frac{x}{4} \right) \), modify the inverse quantizer such that each reconstructed value is still the centroid of each quantization interval. Re-sketch the quantizer’s and the inverse quantizer’s input-output relationship.

Due date: November 19 in class