EECS 360 Signal and System Analysis

Lab 9. Sampling and Signal Reconstruction

1. Consider the system below:

   ![Block Diagram]

   a. Describe what is taking place in this block diagram.
   b. Blocks “A” and “B” represent signals, what is the relationship between these two signals?
   c. “Ts” is the sampling period. In order for the system to function without aliasing, what relationship must exist between signal “A” and Ts?

2. Consider an analog signal \( x_a(t) = \cos(20\pi t), 0 \leq t \leq 1 \). Sample this signal at \( T_s = 0.01, 0.05, 0.1 \) second intervals.
   a. What is the frequency of \( x_a(t) \)?
   b. Produce a stem plot of all three sampled sequences. Use 3 subplots contained in a single figure.
   c. From the stem plots, comment on which sequences are over sampled, under sampled, or ideally sampled.

3. Reconstruct the analog signal \( y_a(t) \) using the following techniques. Use the following time vector for all the reconstruction plots, \( t_a = [0 : 0.001: 1] \).
   a. Reconstruct the signal using rectangular pulses.
      
      *Hint: use “rectpuls” function.*
   b. Reconstruct the signal using triangle pulses.
      
      *Hint: use “tripuls” function.*
   c. Reconstruct the signal using sinc interpolation (see example on next page).
   d. Reconstruct the signal using spline interpolation
   e. Plot the three rectangular pulse reconstructed signal (3 subplot, 1 figure)
   f. Plot the three triangular pulse reconstructed signal (3 subplot, 1 figure)
   g. Plot the three sinc interpolation reconstructed signal (3 subplot, 1 figure)
   h. Plot the three spline interpolation reconstructed signal (3 subplot, 1 figure)
   i. Comment on the results, which interpolation works the best? Why?
   j. What sampling frequencies reconstructed better than others?
Sinc interpolation example:

Formula: \( y_a(t) = \sum_{n=-\infty}^{\infty} x_a(nT_s) \frac{\sin[\pi(t - nT_s)/T_s]}{\pi(t - nT_s)/T_s} = \sum_{n=-\infty}^{\infty} x_a(nT_s) \text{sinc}[F_s\pi(t - nT_s)] \)

\[
\text{for } n = 1: \text{length}(\text{delta})
\hspace{1em} t = 0: \text{delta}(n):1;
\hspace{1em} x = \cos(20*\pi*t);
\hspace{1em} Fs = 1/\text{delta}(n);
\hspace{1em} \% \text{ Reconstruction using sinc function:}
\hspace{1em} X1(n,:) = x*\text{sinc}(Fs*(\text{ones}(\text{length}(t),1)*\text{ta}-t'*\text{ones}(1,\text{length}(\text{ta}))));
\text{end}
\]

4. Calculate the mean squared error of all 12 reconstructed signals
   a. Construct a “bar” graph using the given function “mseplot.m”
      Note: reshape the mse vector into a 3x4 matrix before apply.
   b. Comment on which reconstruction technique produced the lease MSE.