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. “T_s” is the sampling period. In order for the system to function without aliasing, what relationship must exist between signal “A” and T_s?

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

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for n = 1:length(delta)
    t = 0:delta(n):1;
    x = cos(20*pi*t);
    Fs = 1/delta(n);
    % Reconstruction using sinc function:
    X1(n,:)=x*sinc(Fs*(ones(length(t),1)*ta-t'*ones(1,length(ta))));
end
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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.