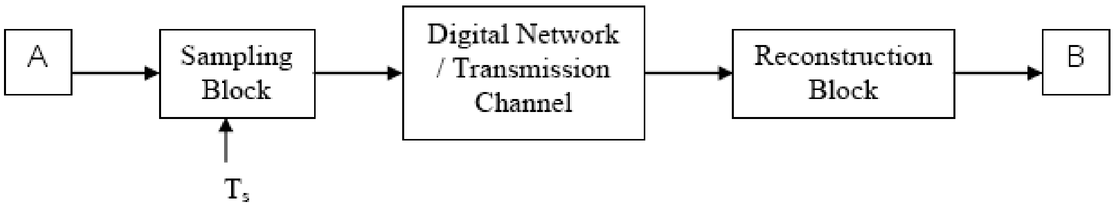
EECS 360 Signal and System Analysis

Lab 9. Sampling and Signal Reconstruction

1. Consider the system below:



    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 $x_a(t) = \cos(20\pi t), 0 \le t \le 1$. 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: $y_a(t) = \sum_{n=-\infty}^{\infty} x_a(nT_s)\frac{\sin\left[\pi\left(t-nT_s\right)/T_s\right]}{\pi\left(t-nT_s\right)/T_s} = \sum_{n=-\infty}^{\infty} x_a(nT_s)\,\mathrm{sinc}\left[F_s\pi\left(t-nT_s\right)\right]$

```
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
```

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.