



## Experiment No. # 1

### Discretization of signals : Sampling and Reconstruction

#### 1) Objectives:

- a) Signal Sampling and Reconstruction.
- b) Introduction to simulink.

#### 2) Software used:

- a) MATLAB.

#### A. Pre-Lab

- a) Read about analog to digital conversion.
- b) Go through matlab inbuilt function.  
 $\sin()$ ,  $\text{interp1}()$ ,  $\text{length}()$ ,  $\text{ceil}()$

### I. SAMPLING AND RECONSTRUCTION

#### A. Theory

- 1) J. Proakis and D. Manolakis, Digital signal processing: principles, algorithms, and applications

#### B. Procedure

- 1) Generate a sinusoidal signal,

$$x(t) = A \cos(2\pi ft)$$

of frequency 3000 Hz and 1Vpp for four complete cycles.(How do you generate an analoge signal in MATLAB? if no, then what will be the other alternative?) Take  $F_s = 1,00,000$  Hz for ideal signal.

- 2) The discrete time sampled signal is given by replacing  $t$  with  $nTs$

$$x(nTs) = A \cos(2\pi fnTs) \quad (1)$$

where  $n$  is sample number and  $Ts$  is time period of signal having frequency  $F_s$ .

- 3) Generate sampled signal,  $y(t)$ , after sampling  $x(t)$  with sampling frequency  $F_{s1} = 10000\text{Hz}$ .
- 4) Repeat 2 and 3 for different sampling frequencies  $F_{s2} = 6000$  Hz,  $F_{s3} = 12000$  Hz,  $F_{s4} = 4000$  Hz,  $F_{s5} = 5000$  Hz. Is there aliasing ?

- 5) Plot the spectrum of the above generated waves using fourier transform or inbuilt FFT function and identify aliased frequencies.
- 6) For reconstruction of sampled signal pass  $y(t)$  through an interpolator and generate reconstructed signal  $z(t)$  either writing linear interpolation code or using inbuilt function `interp1()`.
- 7) Calculate Mean square error(MSE) between  $x(t)$  and  $z(t)$ . What should be the maximum and minimum value of MSE for different sampling frequencies.
- 8) Calculate MSE for different interpolation techniques.
- 9) **Observation:**
  - a) Plot 5 cycles of input signal for different sampling frequencies.
  - b) Plot Fourier spectrum and determine the aliasing effect.
  - c) Find the MSE for linear interpolation with different sampling rates (Plot MSE Vs  $F_s$ ).
  - d) Repeat MSE VS  $F_s$  for different interpolation techniques.
  - e) Perform sampling and Interpolation in simulink.
- 10) **Conclusion:**
  - a) Use different sampling rates and conclude MSE observation?
  - b) Use different types of interpolation(linear, spline, cubic spline) and conclude which one is the best?

## II. INTRODUCING SIMULINK

- 1) Open simulink and create a model file with .slx extension.
- 2) Find various sources(sinewave, binary sequence, random sequence) and sinks(display, constellation diagram, to workspace) etc.
- 3) Drag the various functions to model file.
- 4) Search for matlab function in simulink blockset.
- 5) Repeat all the 'Procedure' steps and recreate the sampling of discrete signal into simulink.

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**Well Done**

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