Experiment No.-3: Sampling and reconstruction of signals

1. Overview

The objective of this lab is to teach you the effects of sampling on continuous time signals.

2. Sampling

The sampling theorem specifies conditions under which a bandlimited continuous-time signal can be completely represented by discrete samples. The resulting discrete-time signal $x[n] = x_c(nT)$ contains all the information in the continuous-time signal so long as the continuous-time signal is sufficiently bandlimited in frequency, i.e., $X_c(j\Omega) = 0$ for $|\Omega \geq \pi/T|$. When this condition is satisfied, the original continuous-time signal can be perfectly reconstructed by interpolating between samples of $x[n]$.
Consider the sinusoidal signal,

$$x(t) = sin(\Omega_0 t)$$

If $x(t)$ is sampled with frequency $\Omega_s = 2\pi/T$ rad/sec, then the discrete-time signal $x[n] = x(nT)$ is equal to

$$x[n] = sin(\Omega_0 nT)$$

Assume sampling frequency is fixed at $\Omega_s = 2\pi(8192)$ rad/sec.

1. Assume $\Omega_0 = 2\pi(1000)$ rad/sec and define $T = 1/8192$. Create the vector `n=[0:8191]`, so that `t=n*T` contains 8192 samples in the interval $0 \leq t \leq 1$. Create a vector which contains the samples of $x(t)$.
2. Display first 50 samples of $x[n]$ versus n using `stem`. Display the first fifty samples of $x(t)$ versus the sampling time using `plot`.

Note: `plot` displays a continuous-time signal given the samples in `x`.

3. Exercise

1. Write a program in MATLAB to sample the CT signal, $x(t) = cos(2\pi 50t) + cos(2\pi 100t) + cos(2\pi 150t)$ for $Fs < 2Fm,\ Fs = 2Fm\ and\ Fs > 2Fm$. Plot the original CT signal and sampled signals for all cases in same figure. Write your observations.

2. Run the piano.m file in MATLAB. Change $Fs = 1000\ Hz$, calculate the aliased frequencies for all the notes of piano. Make your own song by selecting proper notes of piano.