Signals and Systems Laboratory
Indian Institute of Technology Jammu
Experiment No.-8

Objective- (a) Sampling and Reconstruction of a Sinusoidal Signal:

Apparatus- Python+matplotlib.
Theory-
If we sample the continuous-time signal $x_c(t) = cos(4000\pi t)$ with sampling period $T = \frac{1}{6000}$, we obtain $x[n] = x_c(nT) = cos(4000\pi Tn) = cos(\omega_0 n)$, where $\omega_0 = 4000\pi T = \frac{2\pi}{3}$. In this case, $\Omega_s = \frac{2\pi}{T} = 12000\pi$, and the highest frequency of the signal is $\Omega_0 = 4000\pi$, so the conditions of the Nyquist sampling theorem are satisfied and there is no aliasing. The Fourier transform of $x_c(t)$ is $X_c(j\Omega) = \pi\delta(\Omega - 4000\pi + \pi\delta(\Omega + 4000\pi)$. and Figure 1(a) shows $X_s(j\Omega) = \frac{1}{T}\sum_{k=-\infty}^{\infty} X_c(j(\Omega - k\Omega_s))$, for $\Omega_s = 12000\pi$. Note that $X_c(j\Omega)$ is a pair of impulses at $\Omega = \pm 4000\pi$, and we see shifted copies of this Fourier transform centered on $\pm\Omega_s$, $\pm 2\Omega_s$, etc. Plotting $X(e^{j\omega})$ $= X_s(j\omega T)$ as a function of the normalized frequency $\omega = \Omega T$ gives Figure 1 (b), where we have used the fact that scaling the independent variable of an impulse also scales its area, i.e., $\delta\frac{\omega}{T} = T\delta(\omega)$. Note that the original frequency $\Omega_0 = 4000\pi$ corresponds to the normalized frequency $\omega_0 = 4000\pi T = \frac{2\pi}{3}$, which satisfies the inequality $\omega_0 < \pi$, corresponding to the fact that $\omega_0 = 4000\pi < \frac{\pi}{T} = 6000\pi$. Figure 1 (a) shows the frequency response of the ideal reconstruction filter $H_r(j\omega)$ for the given sampling rate of $\omega_s = 12000\pi$. It is clear from this figure that the signal that would be reconstructed would have frequency $\omega_0 = 4000\pi$, which is the frequency of the original signal $x_c(t)$.

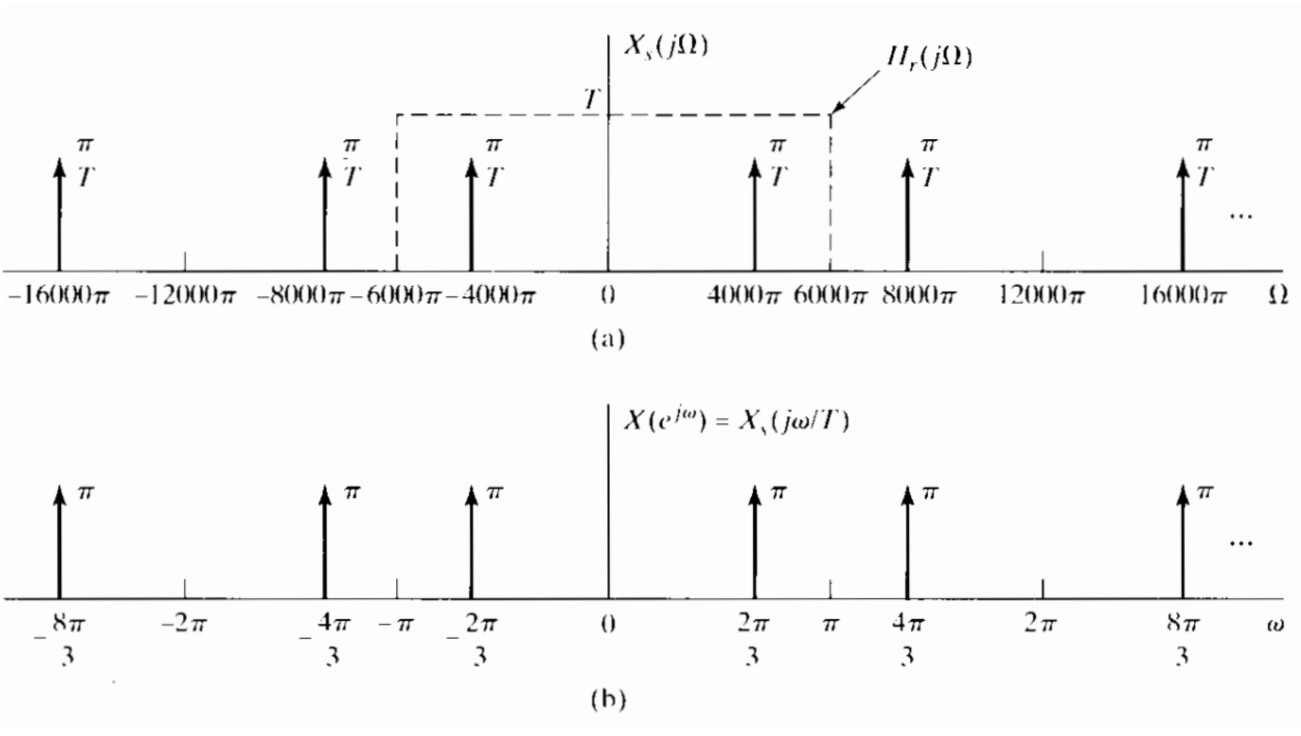

Figure 1: Continuous-time (a) and Discrete-time (b) Fourier transforms for sampled cosine signal with frequency Ω_0= 4000π and sampling period $T = \frac{1}{6000}$.

Algorithm-

a. Start the process.

b. Frequency domain analysis of time delay and time scaling property of signal x(n).

c. Execute the program.

d. Plot the output for each function.

e. Stop the process.

Observations-
Result- Performed frequency domain analysis of time delay and time scaling property of signal x(n).
Precautions:-

- Program must be written carefully to avoid errors.
- Programs can never be saved as standard function name.
- Commands must be written in proper format.