Signals and Systems Laboratory
Indian Institute of Technology Jammu
Experiment No.-2

Objective- Sampling and Reconstruction. Given sequence: x1 = sin(2πft). Here f= 20 Hz. Sampling rate: 35Hz, 50Hz, 100Hz.
Apparatus- python+matplotlib
Theory-
Sampling:
The sampling is the process of conversion of continuous-time signal into discrete-time signal. The time interval between successive samples is called sampling time or sampling period. The inverse of sampling period is called sampling frequency. For reconstructing the continuous-time signal from its discrete-time samples without any error, the signal should be sampled at a sufficient rate that is determined by the sampling theorem.
Nyquist Sampling Theorem:
If a signal is band limited and its samples are taken at sufficient rate then those samples uniquely specify the signal and the signal can be reconstructed from those samples. This condition is known as Nyquist sampling theorem.
The phenomenon of high frequency component getting the identity of low frequency component during sampling is called aliasing. When sampling frequency f_s is greater tahn equal to $2f_m$, the sampling rate is called Nyquist rate.

$$f_s \geq 2f_m$$

Signal Reconstruction Process:
The process of reconstruction, also commonly known as interpolation, produces a continuous-time signal that would sample to a given discrete-time signal at a specific sampling rate. Reconstruction can be mathematically understood by first generating a continuous-time impulse train.

$$x_{imp}(t) = \sum_{n=-\infty}^{\infty} x_s(n)\delta(t - nT_s)$$

from the sampled signal x_s with sampling period T_s and then applying a low pass G that satisfies certain conditions to produce an output signal $\bar{x}$. If G has impulse response g, then the result of the reconstruction process is given by the following computation, the final equation of which is used to perform reconstruction in practice.

$$\begin{aligned}
\bar{x}(t) &= (x_{imp} * g)(t) \\
&= \int_{-\infty}^{\infty} x_{imp}(\tau)g(t-\tau)d\tau \\
&= \int_{-\infty}^{\infty} \sum_{n=-\infty}^{\infty} x_s(n)\delta(\tau - nT_s)g(t-\tau)d\tau \\
&= \sum_{n=-\infty}^{\infty} x_s(n) \int_{-\infty}^{\infty} \delta(\tau - nT_s)g(t-\tau)d\tau \\
&= \sum_{n=-\infty}^{\infty} x_s(n)g(t - nT_s)
\end{aligned}$$

Observations-
Result- Performed sampling and reconstruction process on given signals.
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.