Title of the experiment:

Natural Sampling and Flat-Top Sampling Using Op-Amp

Theory:

Sampling is the process of converting analog signal to discrete signal. It is the first stage in any A/D Convertor circuits. It is a fundamental process in the domain of signal processing, serving as the crucial bridge between analog and digital domains. The different methods of sampling are.

1. Ideal sampling
2. Natural sampling
3. Flat-Top sampling

Ideal sampling refers to a theoretical concept in signal processing where a continuous analog signal is sampled at a frequency high enough to accurately capture all its information without any loss or distortion.

Natural sampling selectively captures segments or slices of the waveform using a sampling function. Unlike other sampling methods, natural sampling aims to preserve the essential characteristics and nuances of the original analog signal, particularly focusing on capturing the top portion of the waveform.

In Flat-top sampling, the top portion of the waveform is truncated horizontally, resulting in a flat or level top. Unlike natural sampling, where the goal is to preserve the top portion of the waveform, flat-top sampling involves sacrificing this portion of the signal to achieve specific signal processing objectives.

Natural sampling and Flat-top sampling circuits typically involve the use of operational amplifiers (op-amps) and additional components, such as NPN (Negative-Positive-Negative) and PNP transistors, to implement the necessary signal processing functions. Op-amps may be configured as voltage followers to replicate the input signal, while transistors help control the signal clipping or truncation process. The Nyquist criteria should be ensured in both the cases of sampling.

Applications of sampling techniques vary across different fields, including audio processing, telecommunications, and data compression.

Schematic Diagram:

The circuit schematic of the Natural Sampling and Flat-Top Sampling circuits in eSim is as shown in Figure 1 and Figure 2 respectively:

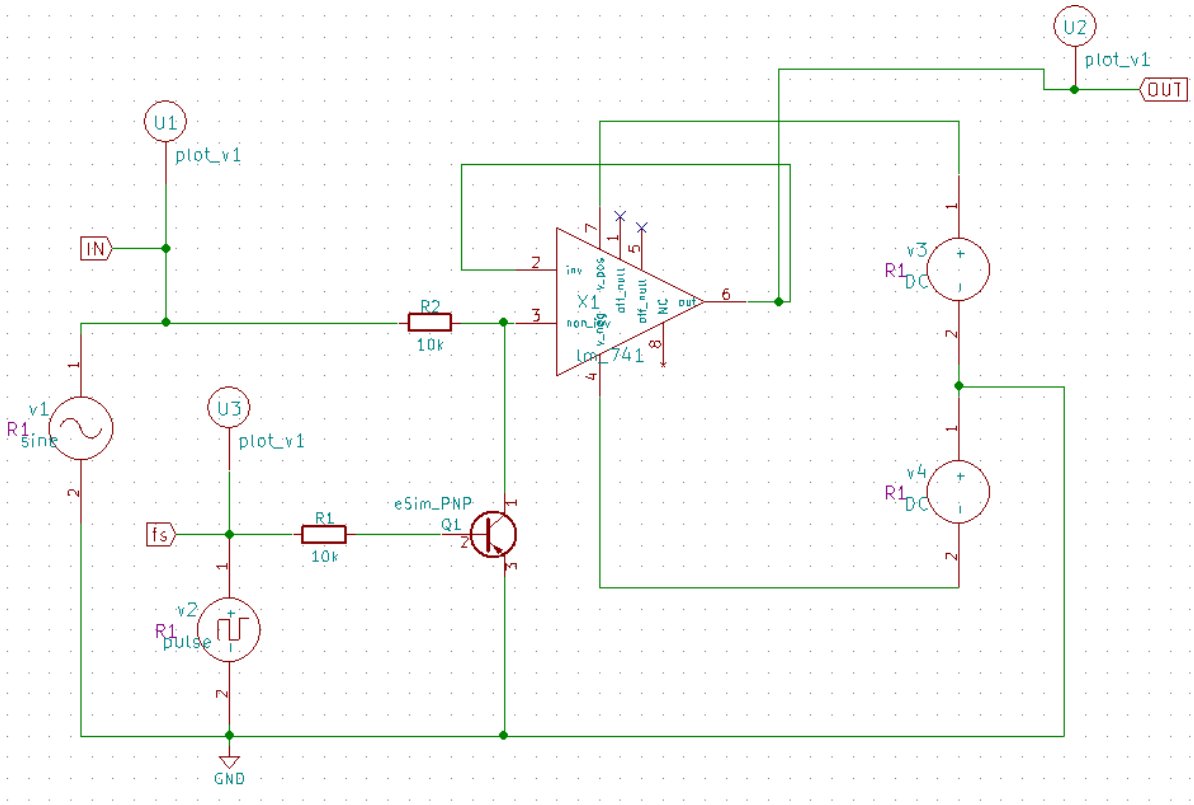

Figure 1: Schematic Diagram of Natural Sampling Circuits Using Op-Amp.

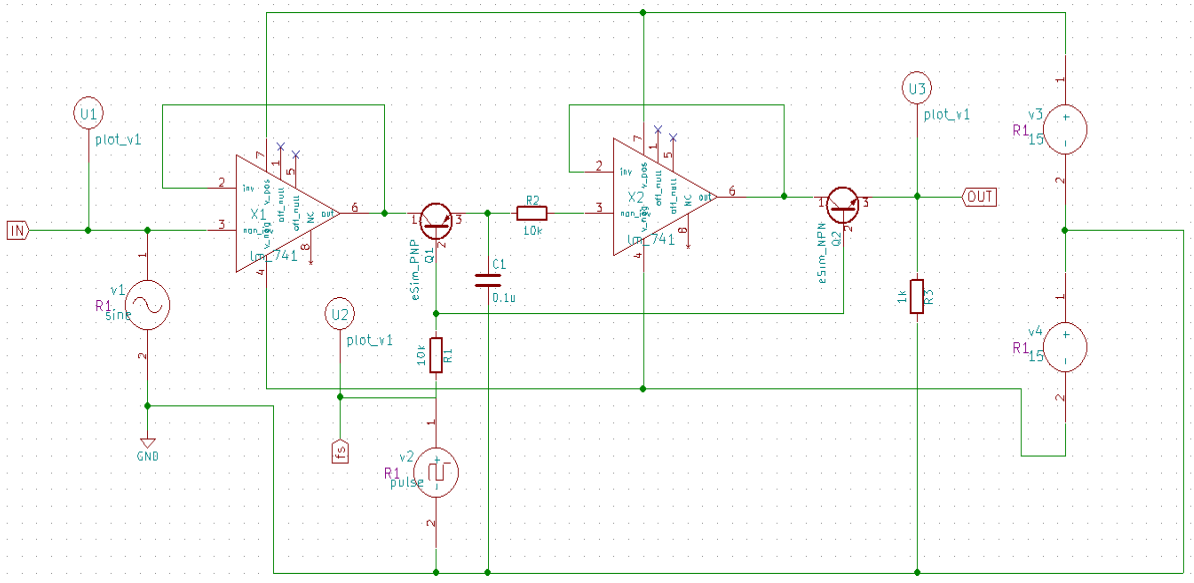

Figure 2: Schematic Diagram of Flat-Top Sampling Circuits Using Op-Amp.

Simulation Results:

1. Ngspice Plots

a. Natural Sampling Circuit

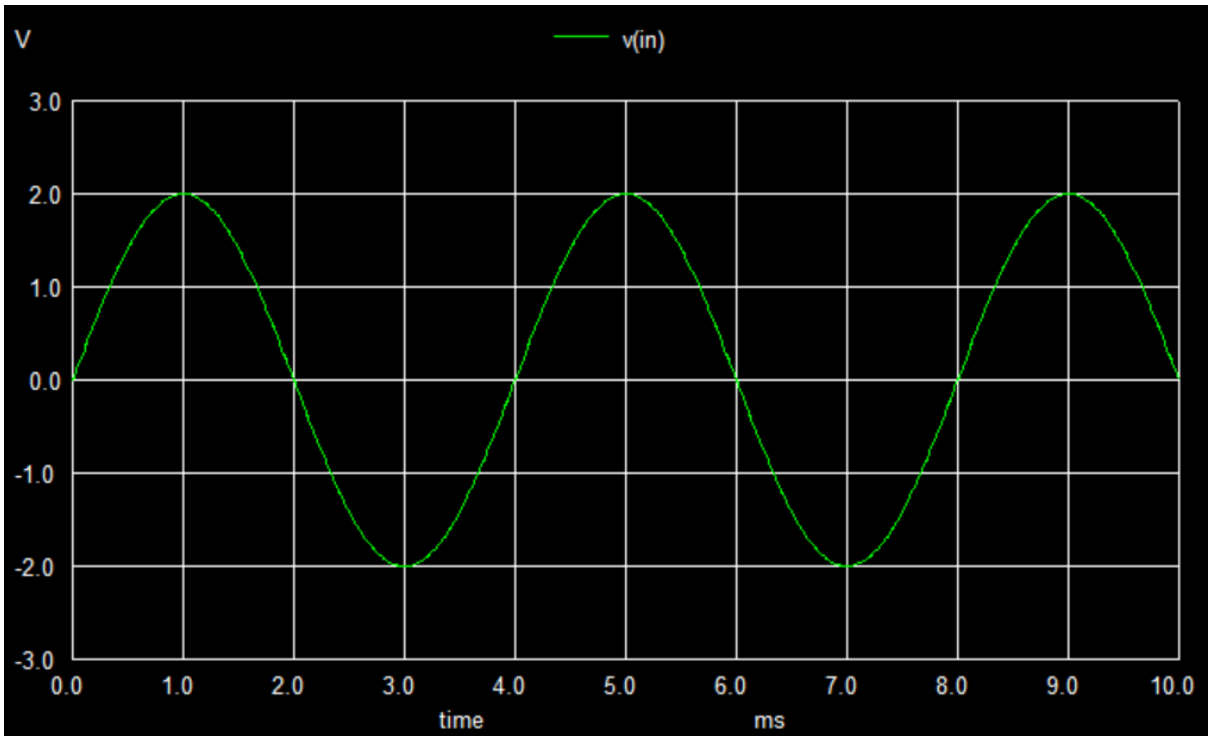

Figure 3: Ngspice Input Plot

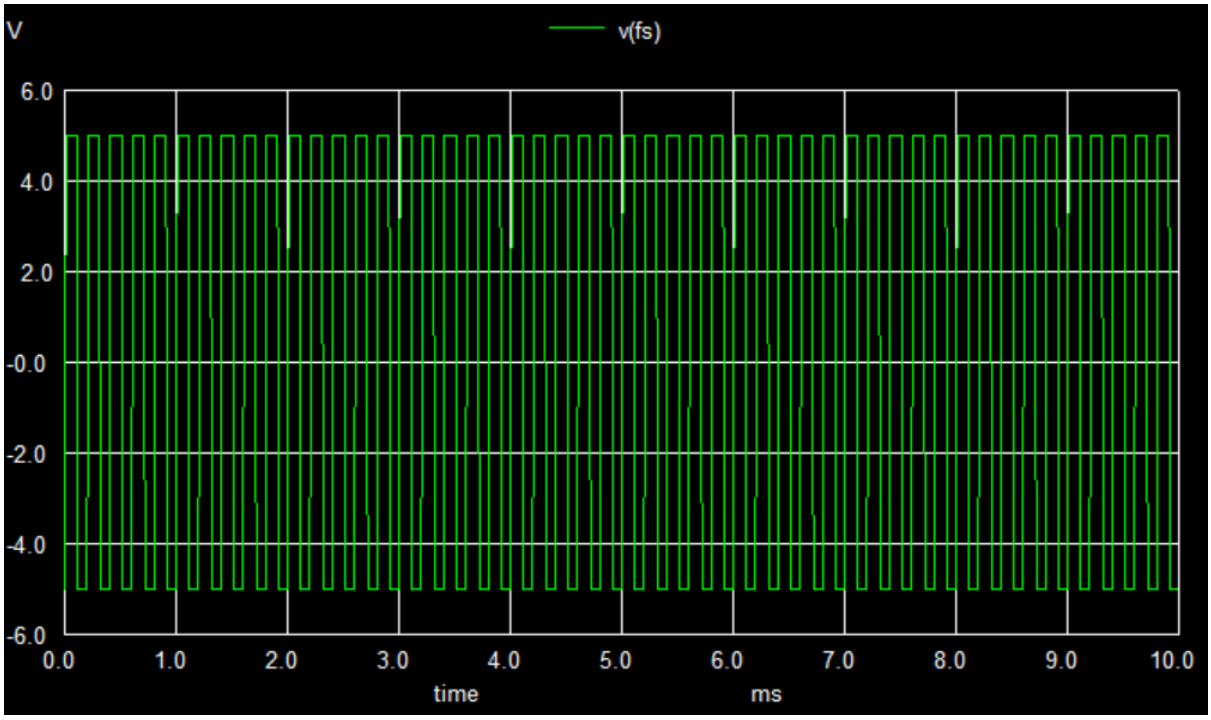

Figure 4: Ngspice Sampling Function Plot

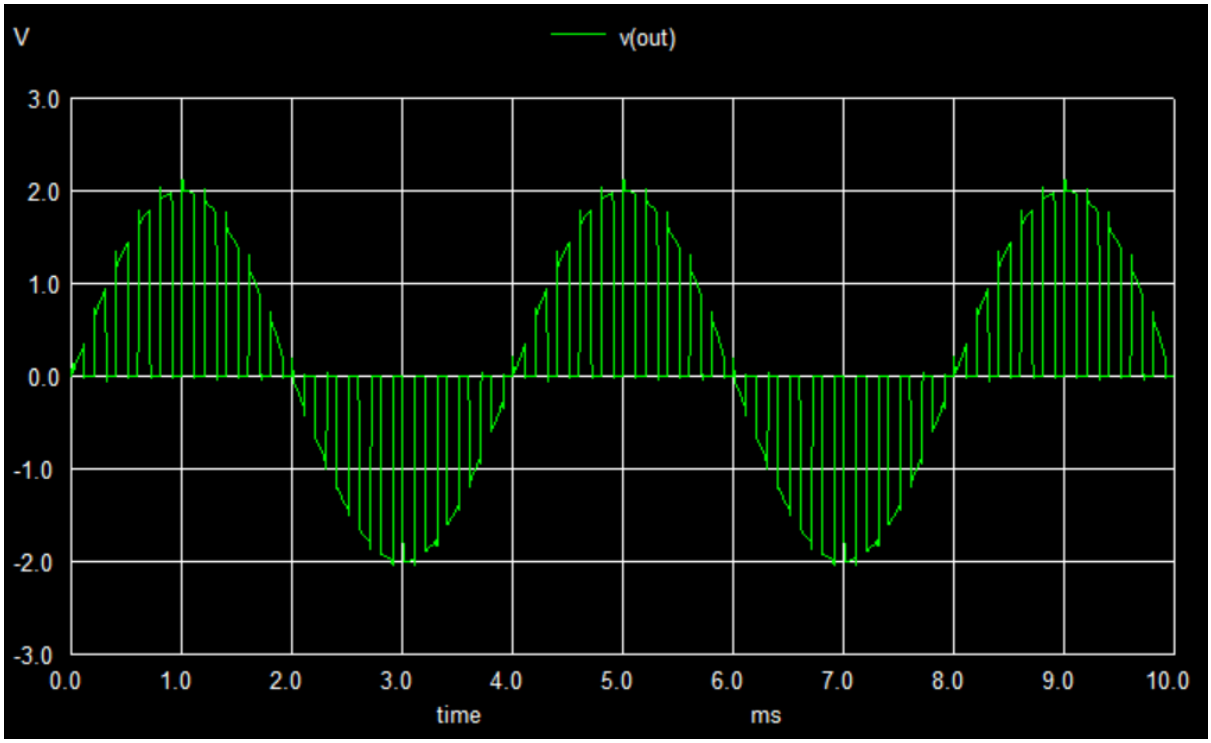

Figure 5: Ngspice Output Plot

b. Flat-Top Sampling Circuit

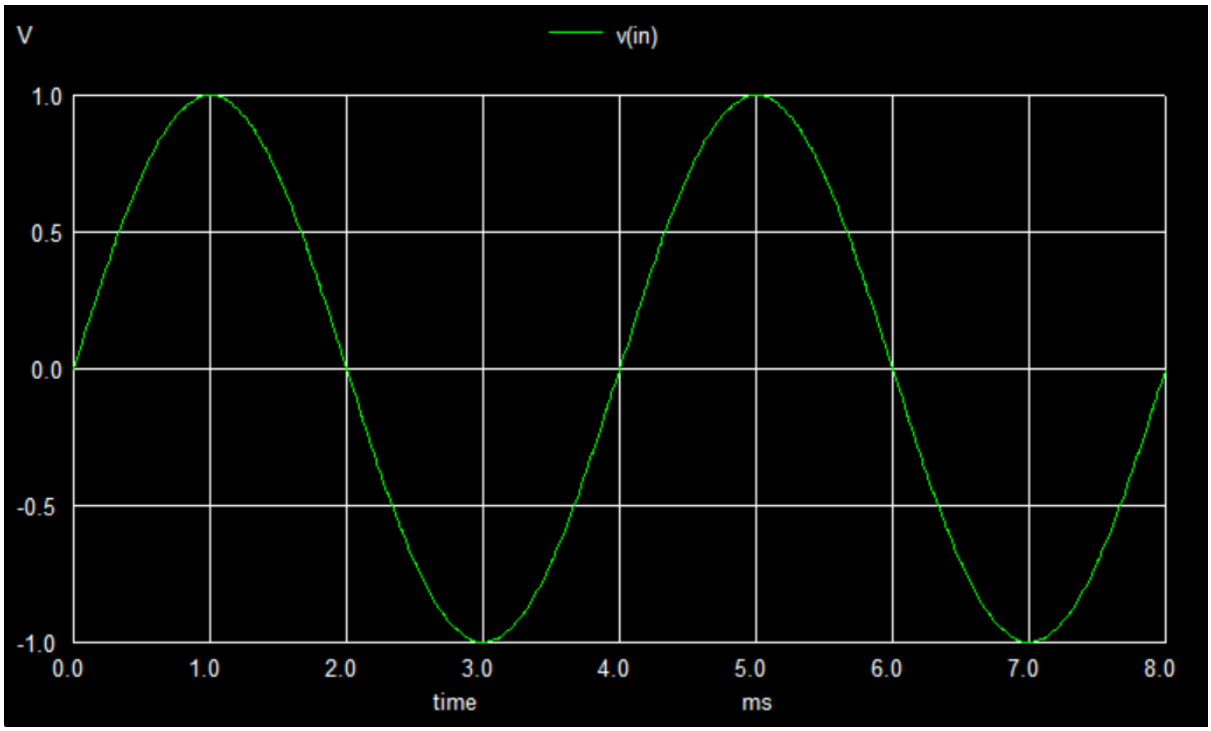

Figure 6: Ngspice Input Plot

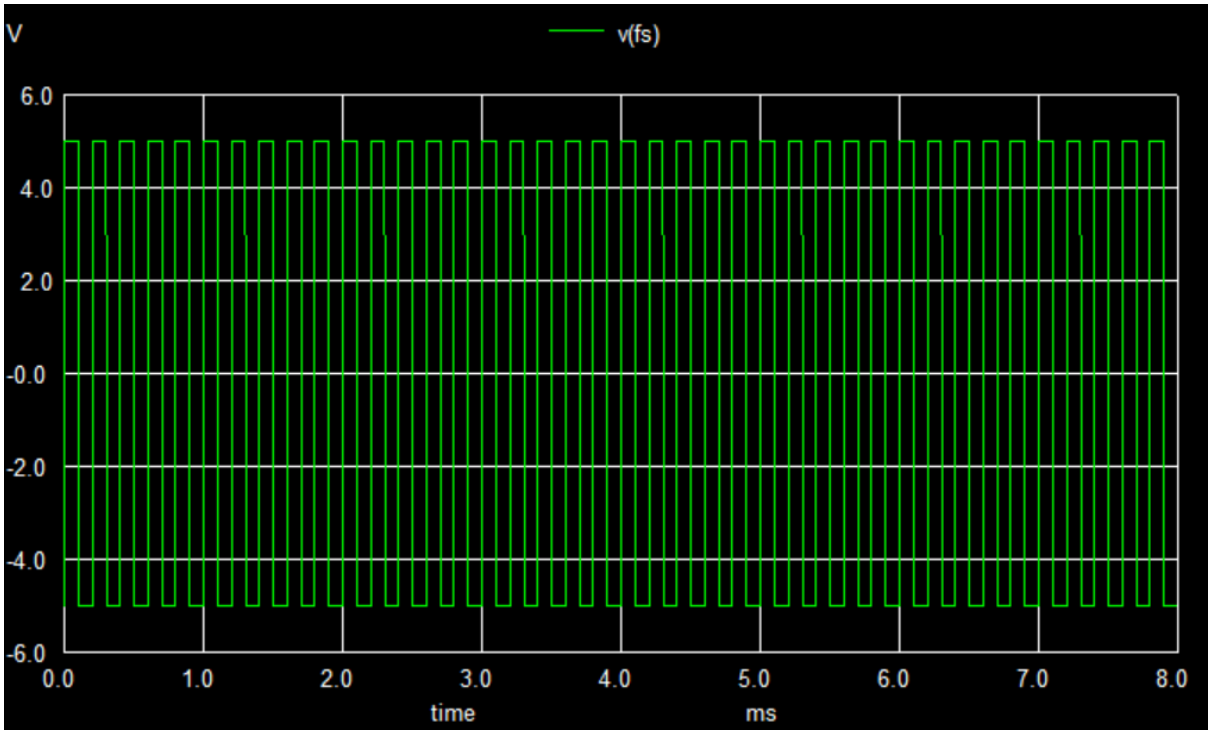

Figure 7: Ngspice Sampling Function Plot

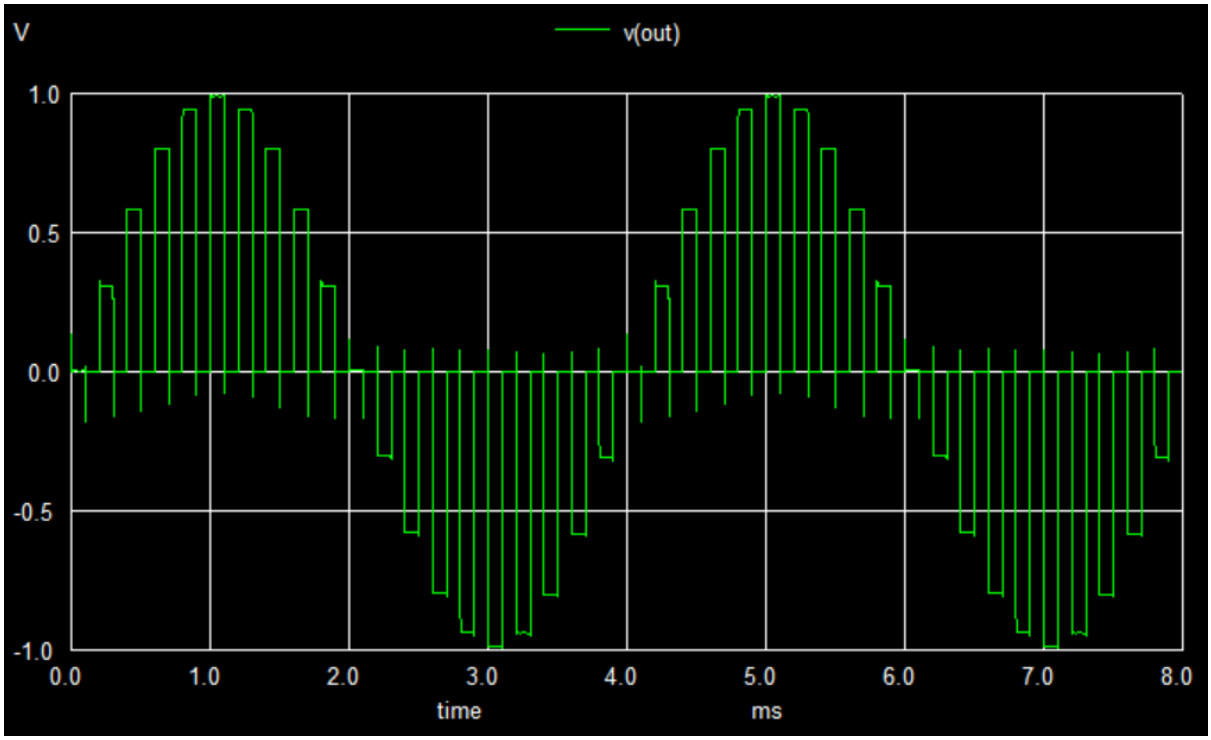

Figure 8: Ngspice Output Plot

2. Python Plots

a. Natural Sampling Circuit

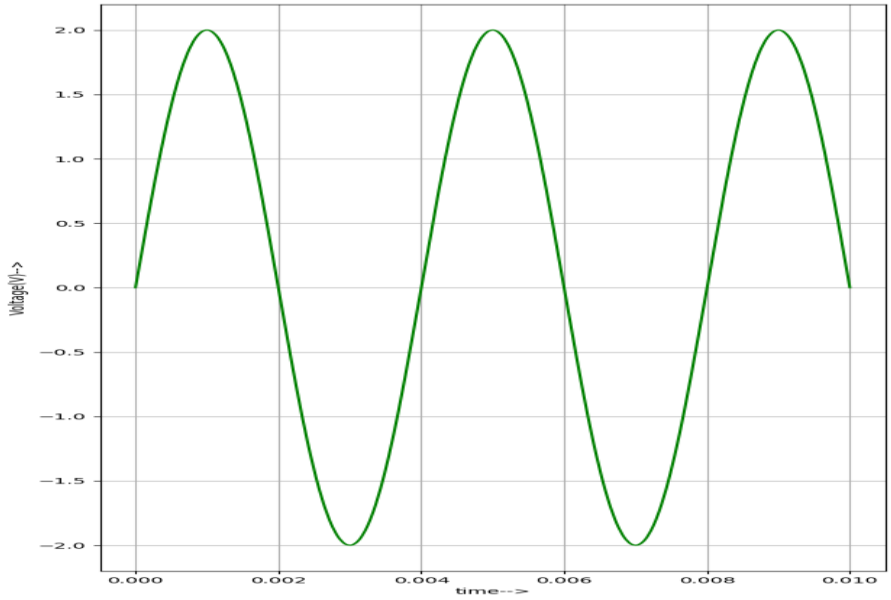

Figure 9: Python Plot Input

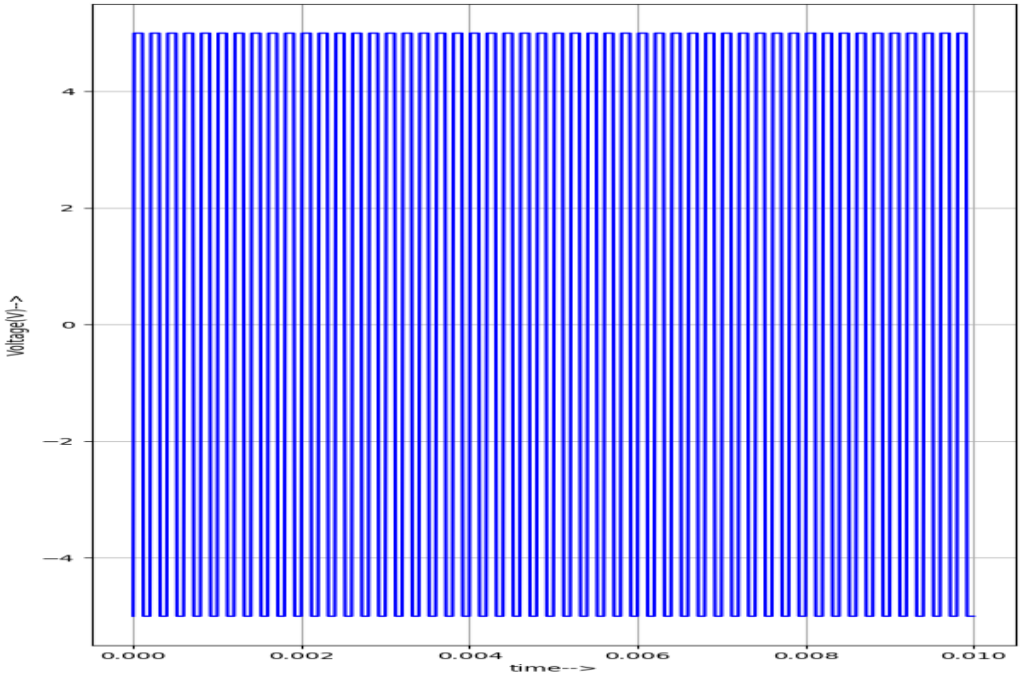

Figure 10: Python Plot of Sampling Function

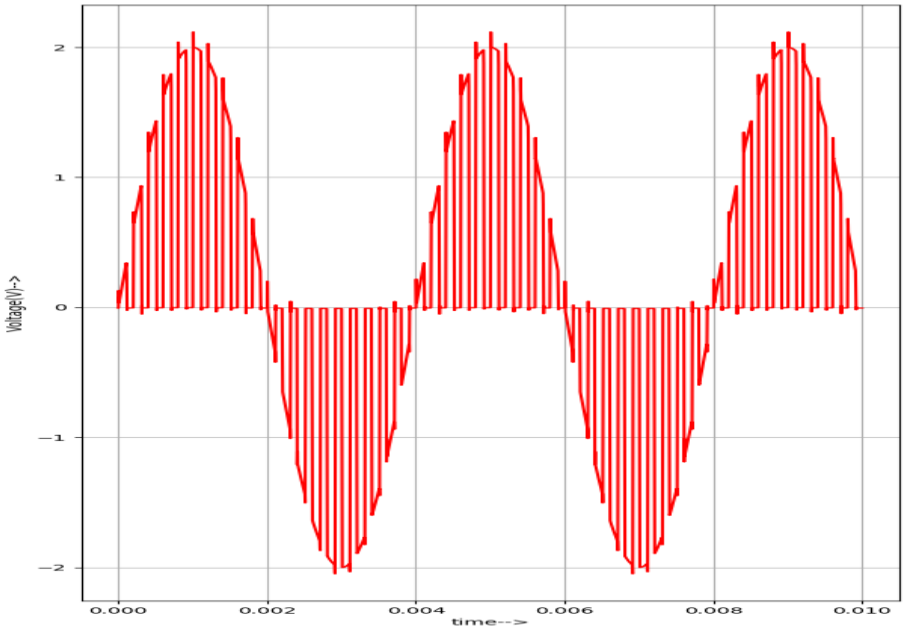

Figure 11: Python Plot Output

b. Flat-Top Sampling Circuit

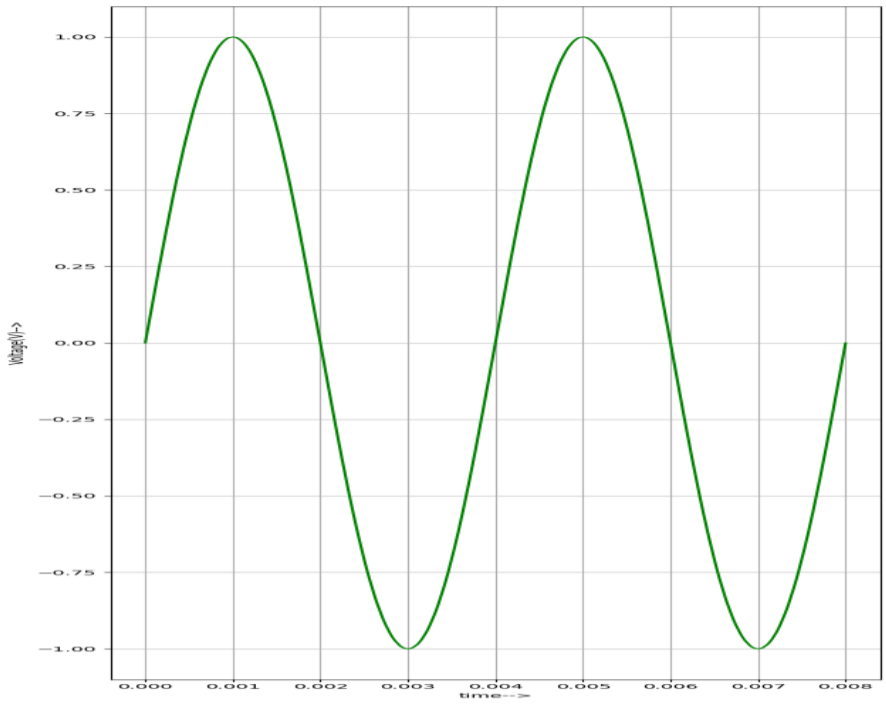

Figure 12: Python Plot Input

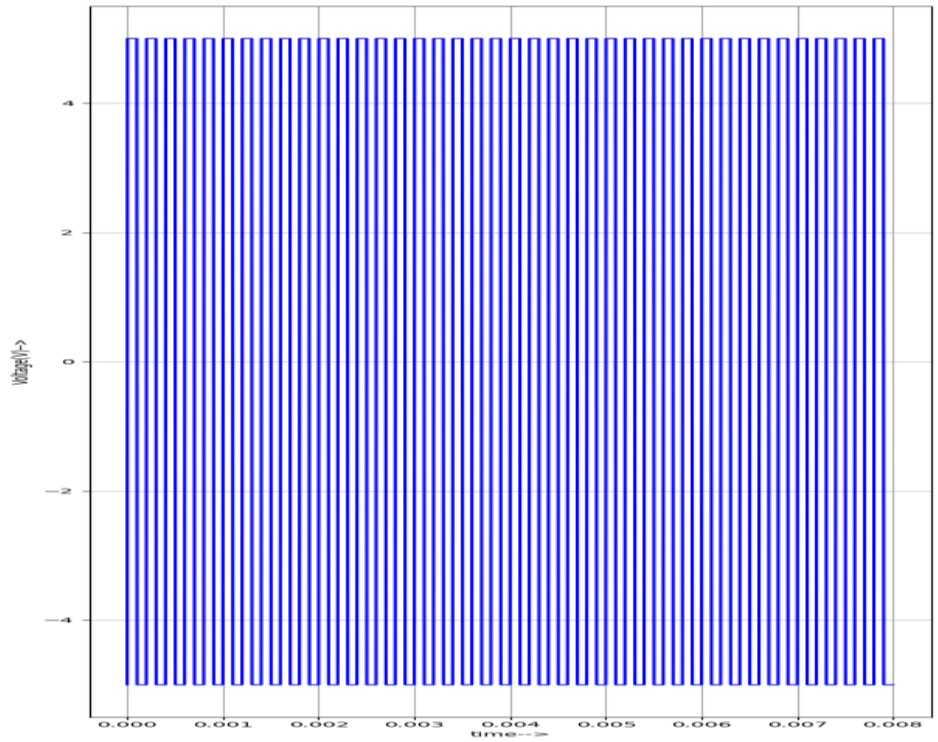

Figure 13: Python Plot of Sampling Function

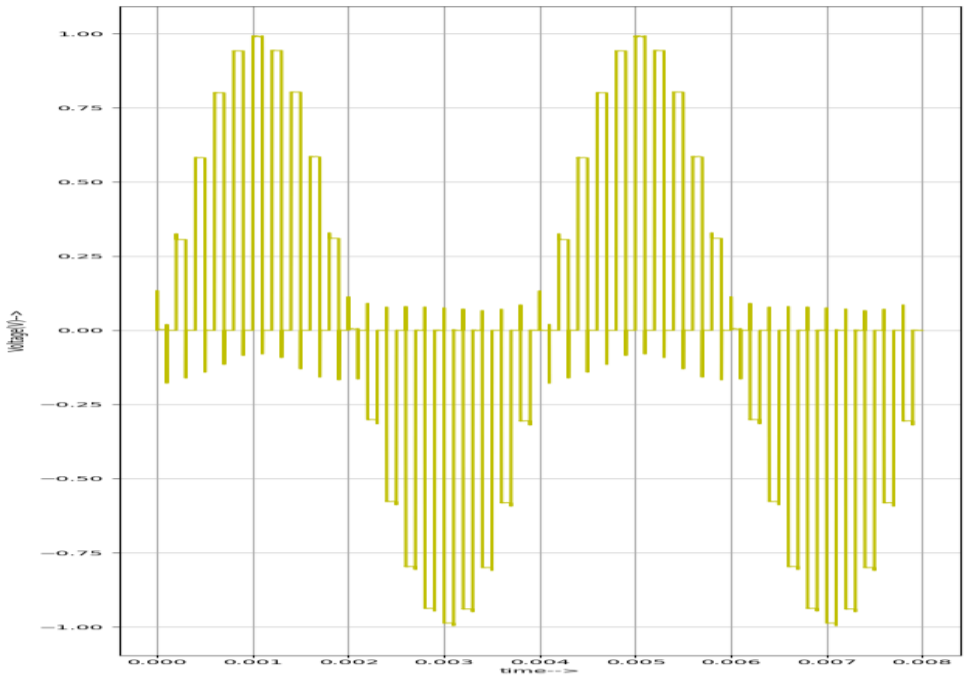

Figure 14: Python Plot Output

Conclusion:

Natural sampling and Flat-top Sampling circuit using op-amp was simulated using esim and appropriate waveforms were obtained.

References:

https://www.tutorialspoint.com/signals_and_systems/signals_sampling_techniques.htm