

Title of the experiment :-

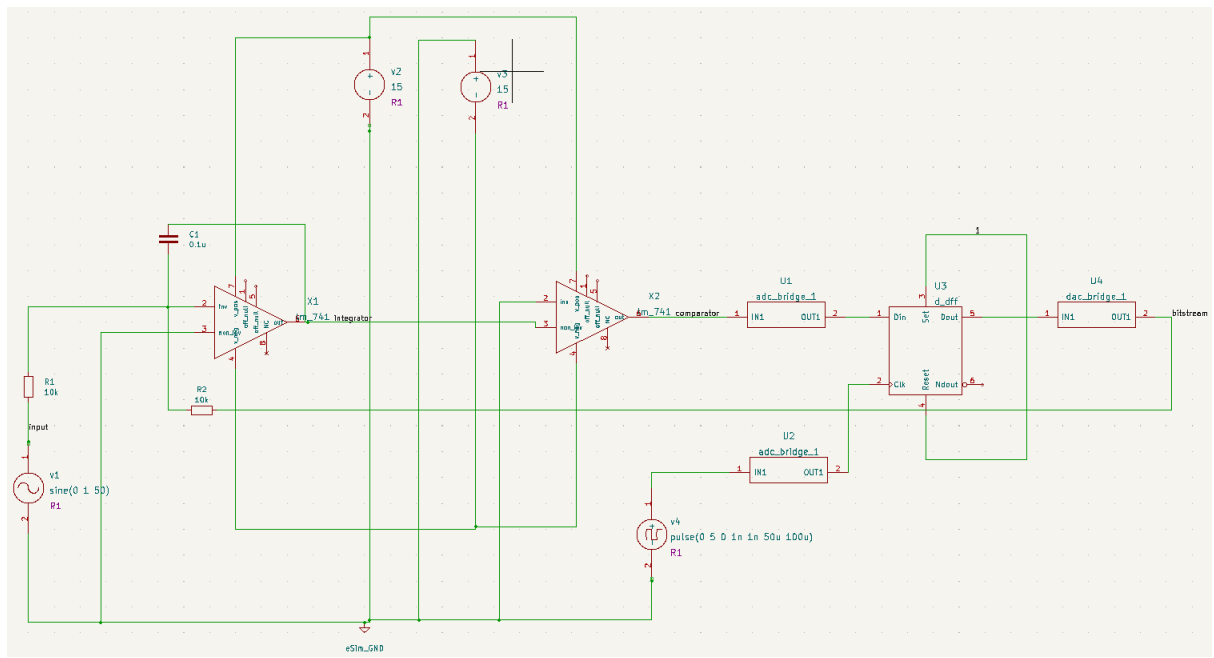
IMPLEMENTATION OF A NOISE-SHAPING DELTA-SIGMA ADC FRONT-END FOR HIGH-RESOLUTION VOICE BAND COMMUNICATION

Theory:-

The **Delta-Sigma Modulator** operates by oversampling an analog input signal and converting it into a high-frequency, 1-bit stream through a continuous feedback loop. The process begins at the **integrator**, which sums the analog input with an inverted feedback signal from the DAC, effectively accumulating the "error" between the input and the digital output. This integrated error is passed to a **comparator** (a 1-bit quantizer) that decides whether the signal is above or below ground, and a **D-Flip-Flop** samples this decision at a high clock rate to produce a synchronized bitstream. By feeding this digital result back into the integrator via a **DAC bridge**, the circuit creates a self-correcting loop that "shapes" quantization noise into higher frequencies. The resulting **Pulse Density Modulation (PDM)** represents the analog signal's amplitude through the density of pulses, where more frequent high pulses correspond to higher analog peaks, allowing for high-resolution reconstruction using a simple low-pass filter.

Schematic Diagram:-

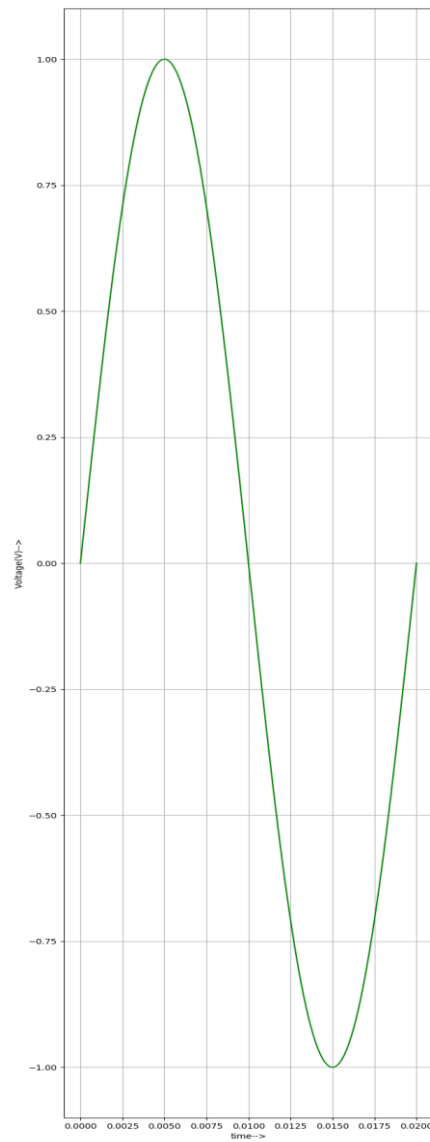
The circuit schematic of the delta sigma modulator in eSim is as shown below:



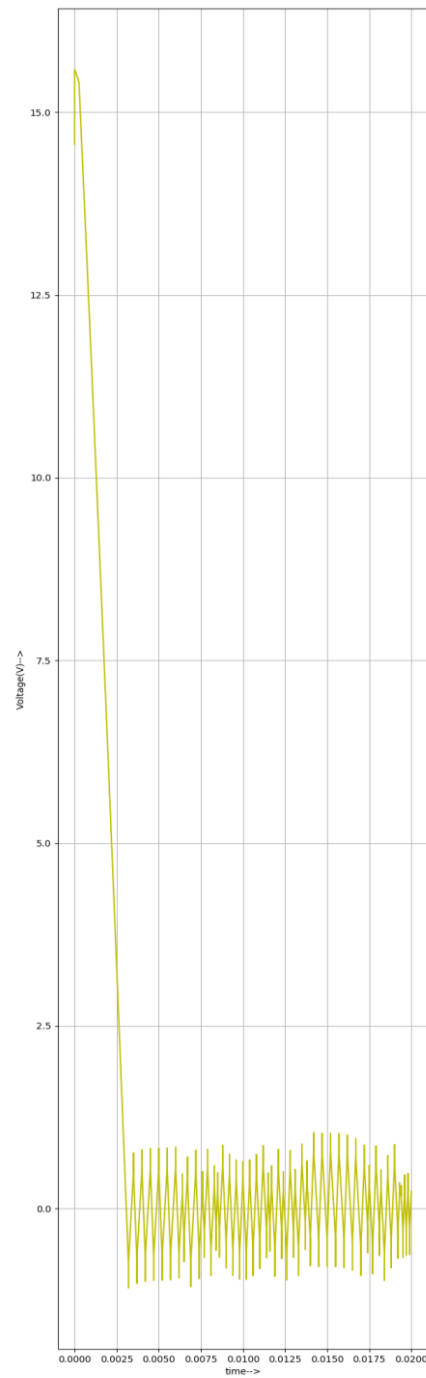
Simulation Results :-

Python Plots:

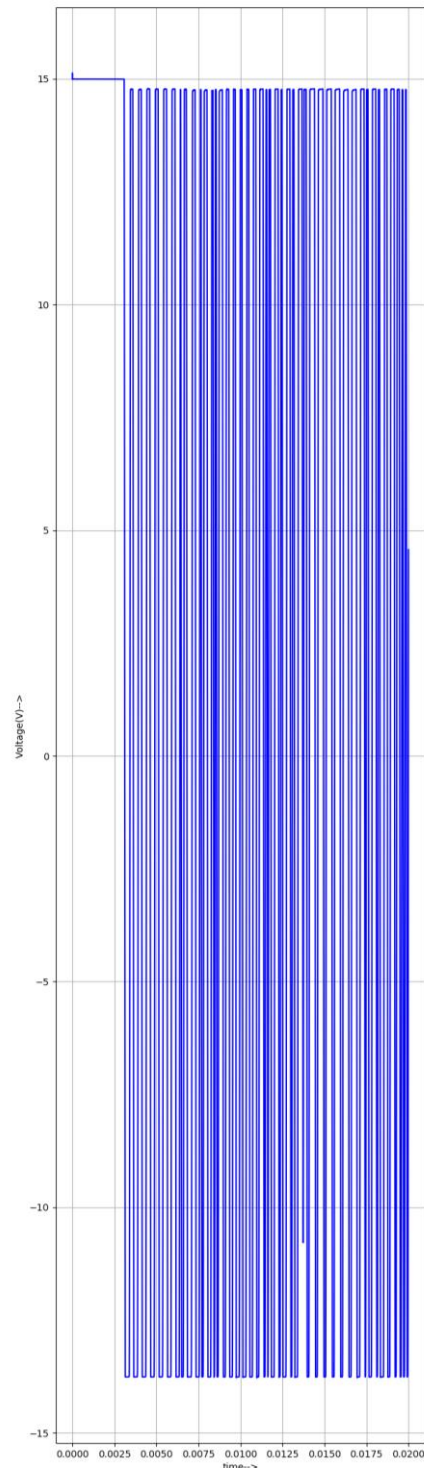
1: input waveform



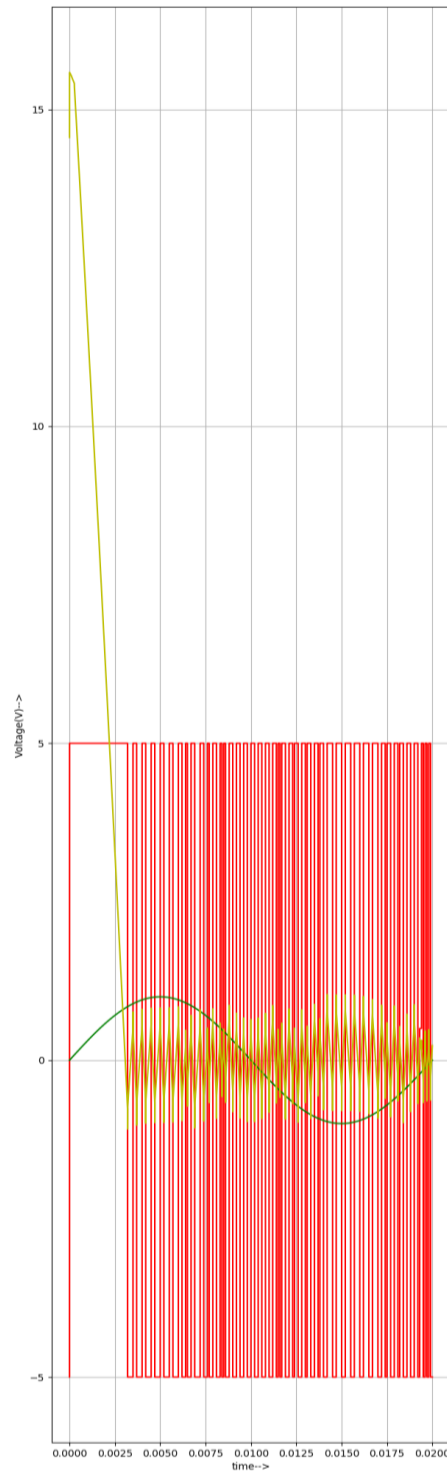
2: integrator waveform



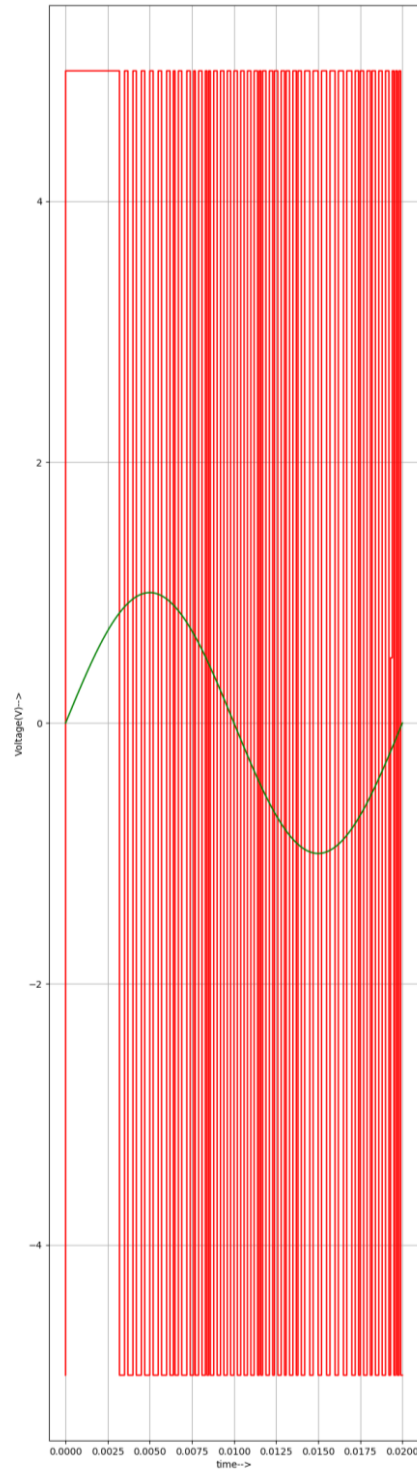
3: comparator waveform



4: input vs output vs integrator waveform



5: input vs output waveform



Conclusion :-

The project successfully demonstrated the design and simulation of a First-Order Delta-Sigma Modulator using the eSim open-source EDA tool. The simulation results confirmed that a high-frequency digital bitstream can accurately represent an analog sine wave through pulse density variations. By optimizing the sampling frequency and integration time constants, the quantization noise was effectively shifted outside the baseband of interest. This confirms the modulator's effectiveness in mixed-signal applications where high resolution is required from low-bit quantizers.

References :-

https://en.wikipedia.org/wiki/Delta-sigma_modulation

<https://www.ti.com/lit/an/slaa013/slaa013.pdf>