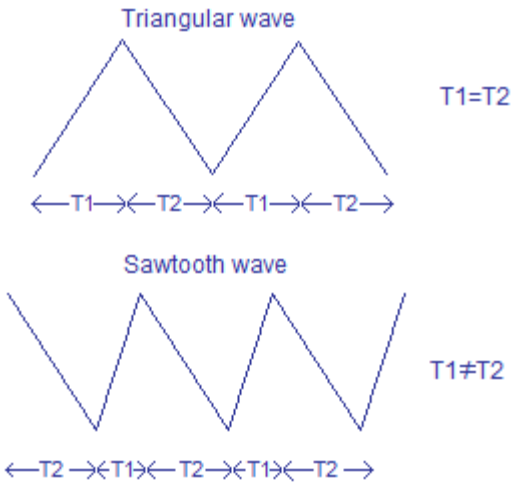
Title of the experiment

Analysis of Sawtooth wave generator in eSim

Theory:

Sawtooth waveform is a type of linear non sinusoidal waveform with a triangular shape in which the rise time and fall time are different. A pure triangular waveform is also linear, non sinusoidal and have a triangular shape but it has equal rise and fall times. The sawtooth waveform can also be called an assymmetric triangular wave. The graphical representation of a triangular and sawtooth waveform are shown in the figure below. T1 is assumed to be the rise time and T2 is assumed to be the fall time.



Like triangular waveforms, sawtooth waveforms are also used in applications like thyristor (SCR, triac etc) switching, sampling, tone/frequency generation, modulation etc.

The sawtooth waveform can be generated by using the **NE555** IC in astable mode and then this 555 timer output is given to **integrator** to get the sawtooth wave form. Here the IC NE555 is used as astable multivibrator with unequal ON and OFF times. Then the resistor R1, R2 and capacitor C2 sets the ON and OFF time periods.

When the power supply is switched ON, capacitor C1 starts charging through resistors R1 and R2. When the voltage across C1 is above 2/3Vcc the upper comparator inside the NE555 swings to positive saturation and this triggers the internal flip-flop. This makes the output (pin 3) of the timer low. Now the capacitor C1 starts to discharge through resistor R2 into pin 7 of the IC. When the voltage across capacitor C1 becomes less than 1/3Vcc, the lower comparator inside the IC switches to positive saturation and this again triggers the internal flip-flop. As a result the output of the timer(pin 3) goes low. This action is repeated and the result will be a square wave at pin 3 of the NE555. The charging time period (ON time) is given by the equation T1= 0.69*(R1+R2)*C1 and the discharging time period (OFF time) is given by the equation T2=0.69*R2*C1.

The output of NE555 is integrated by the inverting active integrator based on opamp IC 741. Resistors R3 and R4 sets the **gain** of the opamp integrator. Resistor R4 in conjunction with capacitor C3 sets the **bandwidth**. Since the integrator is wired in inverting mode, the sawtooth wavform falls when the timer output is high and rises when the timer output is low.

Schematic Diagram:

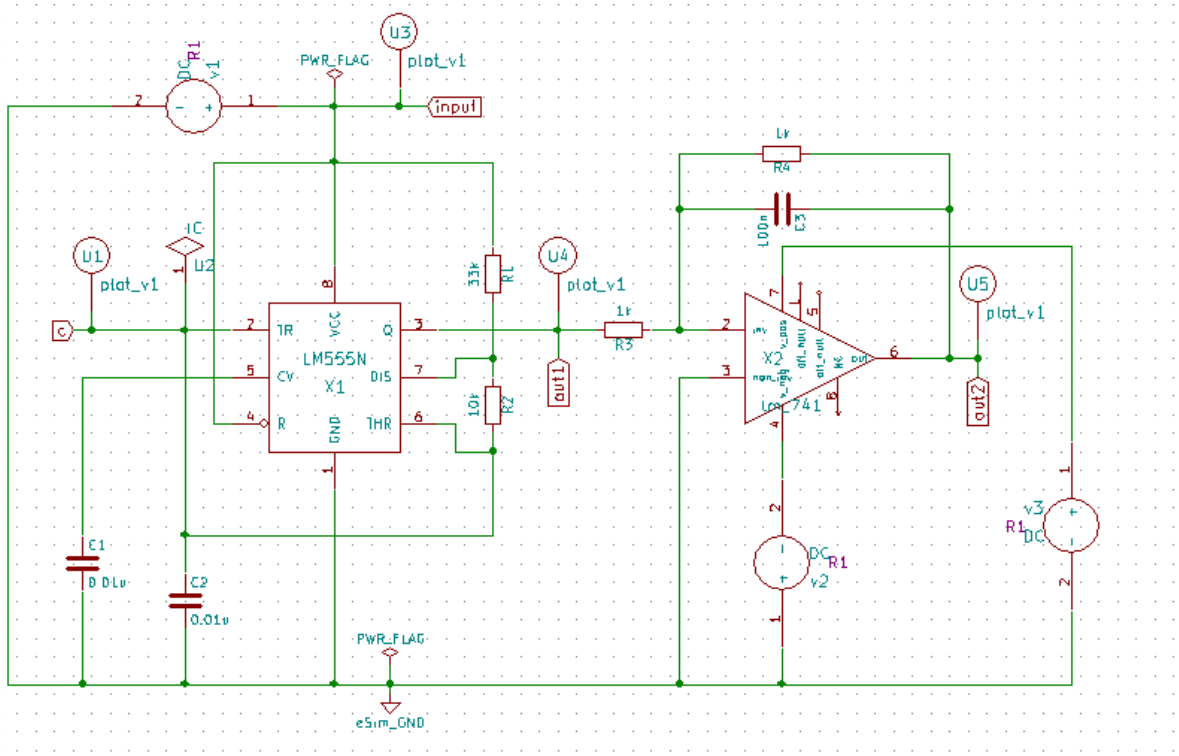


Figure 1: Schematic of Sawtooth Wave Generator

Simulation Results:

1. Ngspice plots:

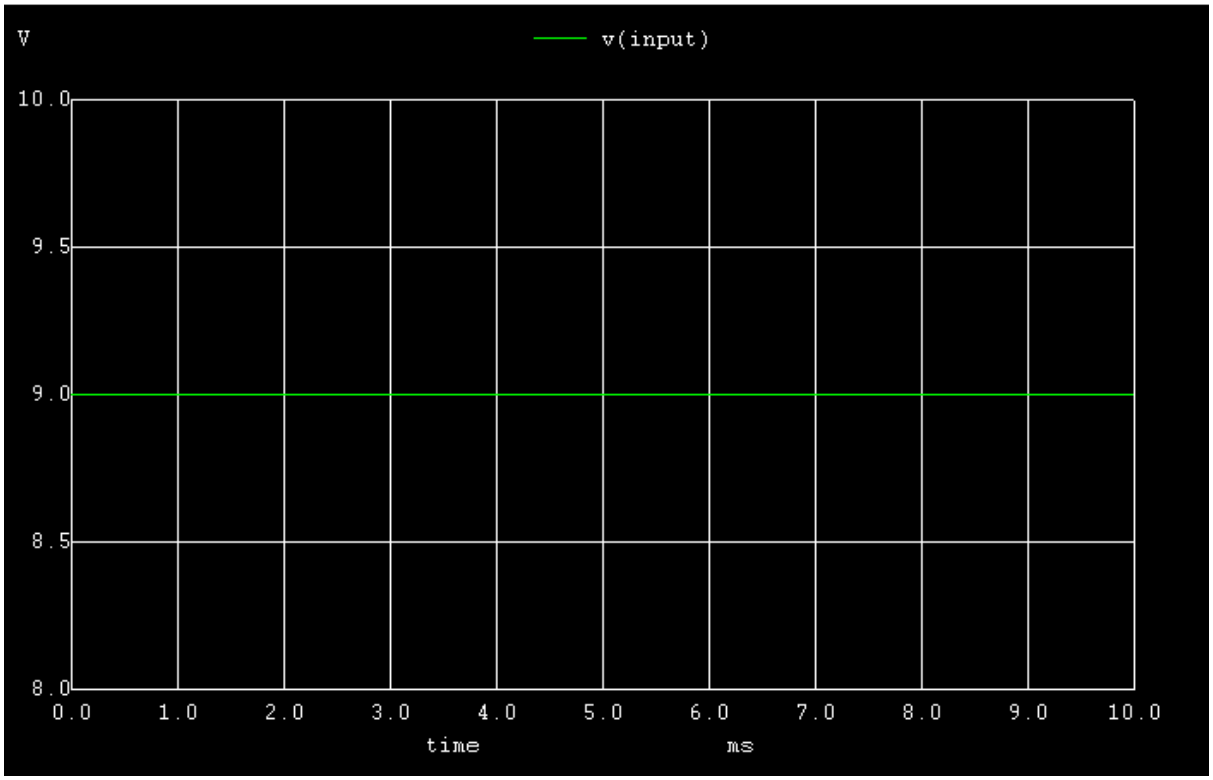


Figure 2: ngspice input plot

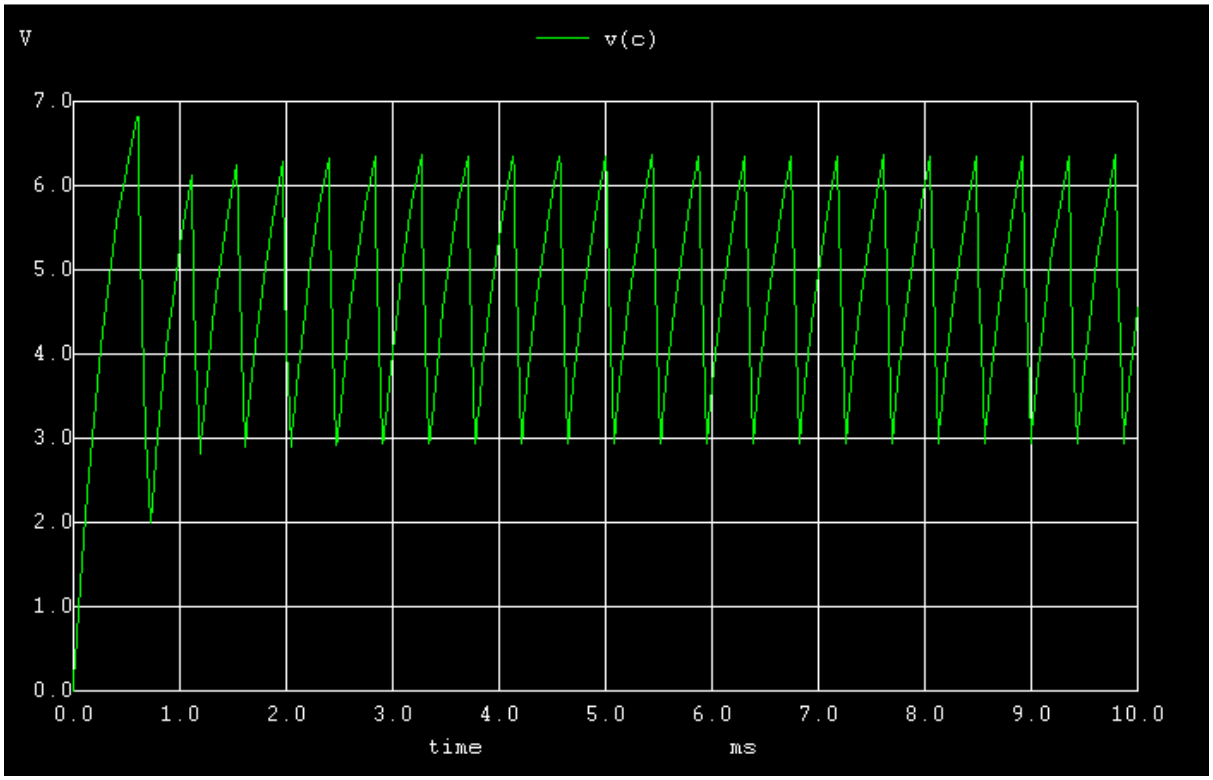


Figure 3: ngspice trigger plot at pin2

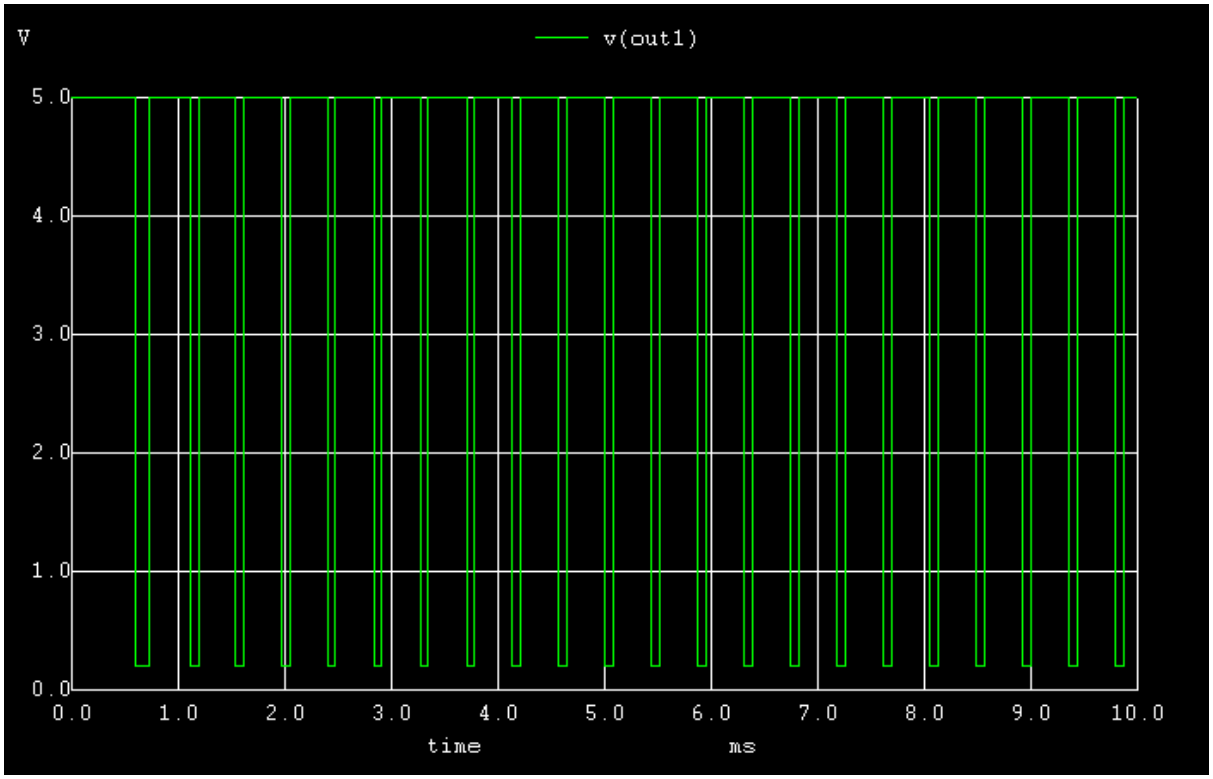


Figure 4: ngspice IC555 output plot (Astable mode)

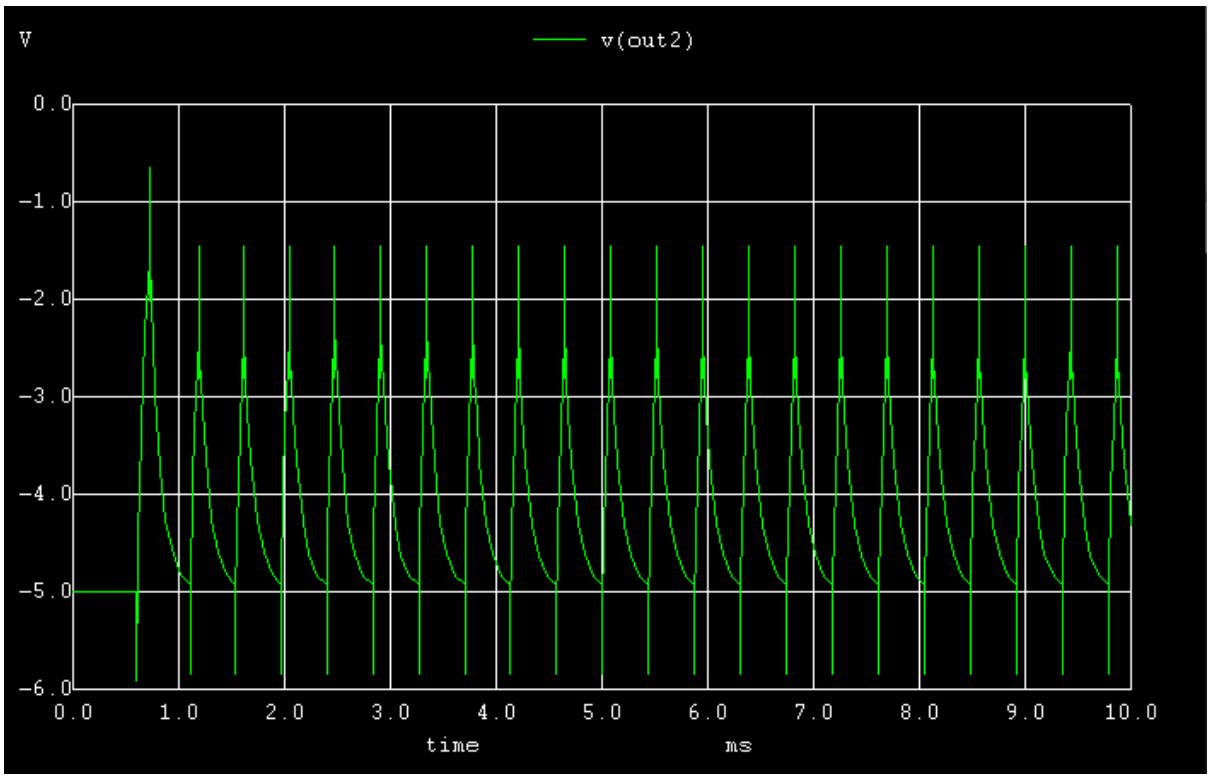


Figure 5: ngspice final output plot (Sawtooth waveform)

Python Plot:

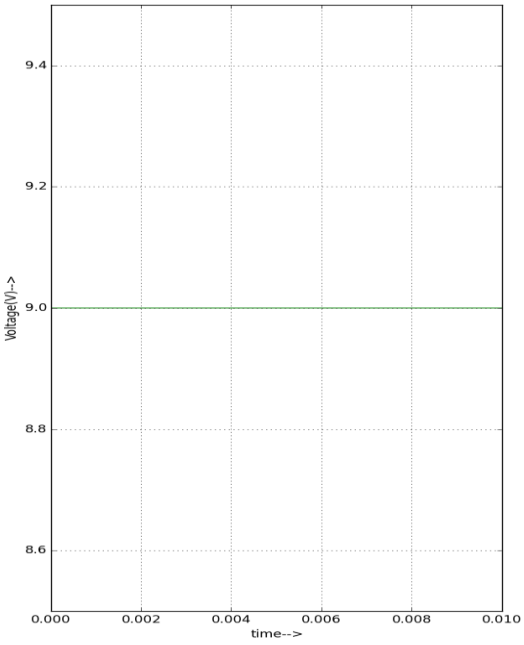


Figure 6: python input plot

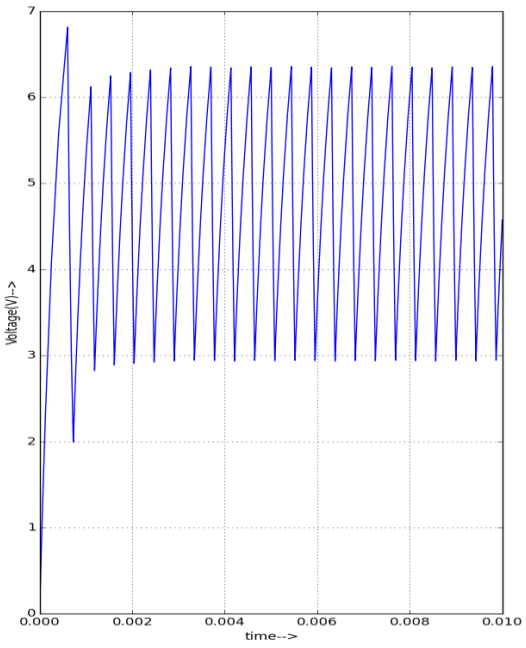


Figure 7: python trigger plot at pin2

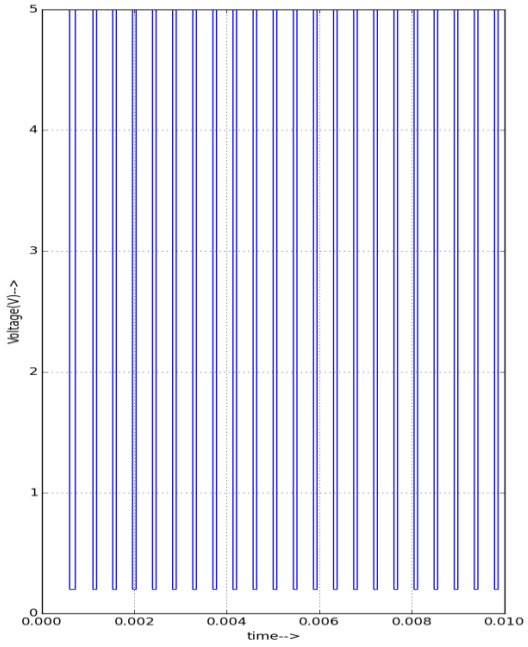


Figure 8: python IC555 output plot

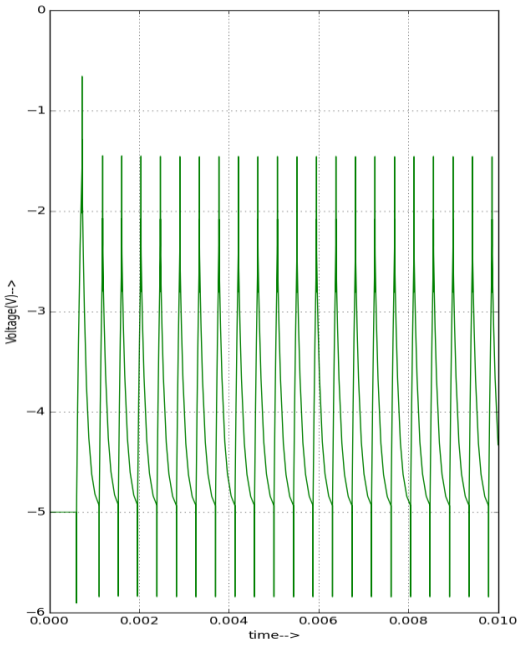


Figure 9: python final output plot

Conclusion :

Thus, we have designed and simulated the sawtooth waveform generator circuit and studied the circuit and the waveform obtained in eSim.

Reference:

1 http://www.circuitstoday.com/sawtooth-wave-generator

2 https://en.wikipedia.org/wiki/Sawtooth_wave