Title of the experiment:

Adjusting trigger points of Inverting Schmitt trigger using diodes

Theory:

A Schmitt trigger is a comparator circuit with positive feedback added. Schmitt trigger is also called as regenerative comparator. A Schmitt trigger circuit converts an arbitrary waveform to a square-wave or pulse. Hence, it is also called a squaring circuit. This circuit is usually used in regenerating digital signal corrupted by noise. Positive feedback eliminates false triggering due to noise voltages if the threshold voltages are made much greater than the input noise voltages.

There are two types of Schmitt triggers: Inverting and Non-inverting. The output voltage V_o is triggered whenever input voltage V_i crosses trigger levels. Any Schmitt trigger will have two trigger points viz., Upper Triggering Point (UTP) and Lower Triggering Point (LTP).

An inverting Schmitt trigger is a type of comparator circuit with hysteresis, used to convert an analog input signal into a digital output signal. The circuit provides noise immunity and a clean digital signal transition even when the input signal is noisy or has a slow edge rate. Many Schmitt trigger circuit applications require UTP and LTP levels that are not equal in magnitude. This is usually achieved by the use of diodes illustrated in Fig1 and Fig2. For the circuit in Fig1, the diode (D1) is in series with resistor R1 is only forward-biased when the op-amp output is positive. In this condition, the UTP is V_{R2}, as before. When V_o is negative D1 is reverse-biased and I_2 is reduced to the op-amp input bias current. The non-inverting terminal is grounded via R2, giving zero level for the LTP. So, this circuit has a positive UTP and a zero voltage LTP.

Fig2 shows a circuit with two different-level trigger points. When V_o is positive, D1 is forward-biased and D2 is reversed. With V_o negative, D2 is forward-biased D1 is reversed. The diode forward voltage (V_f) must be considered when calculating the trigger points for both circuits in Fig1 and Fig2. This is done simply by replacing Vo with ($V_{o(sat)}$-V_f). The voltage divider current should normally be minimum of 100micro Amps for satisfactory diode operation. The diode reverse recovery time (t_{rr}) should be much smaller than the signal minimum pulse width.

The resistors R1, R2 and R3 are determined by using the values of given UTP and LTP,

Assuming R2=10kΩ,

We calculate R1 and R3 using the formula given below,

$$UTP= [(V_{sat} -V_k) * R2] / [R1+R2]$$

$$LTP= [-(V_{sat} -V_k) * R2] / [R2+R3]$$

Where, $V_{(sat)} = V_{cc} -1$ and $V_k = 0.7V$

Schematic Diagram:

The circuit schematic of the Inverting Schmitt trigger circuit with diode D1 and UTP=6V, LTP=0V in eSim is as shown in Figure 1:

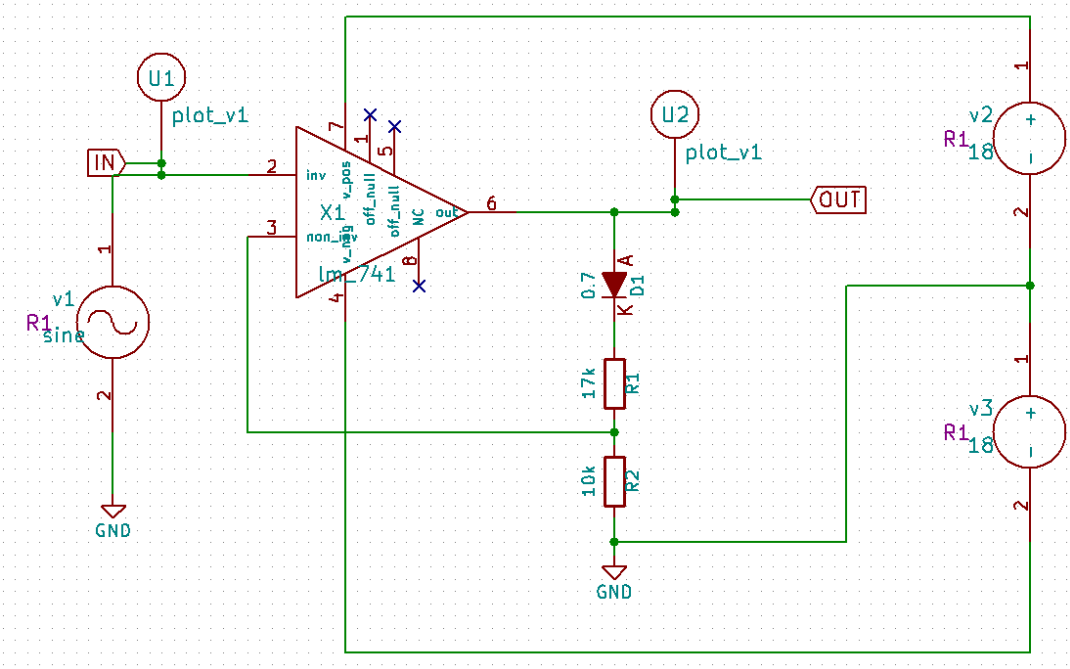

Figure1: Schematic Diagram of Inverting Schmitt trigger circuit with diode D1 with UTP=6V, LTP=0V.

The circuit schematic of the Inverting Schmitt trigger circuit with diodes D1 and D2, UTP=2V & LTP=-1V in eSim is as shown in Figure 2:

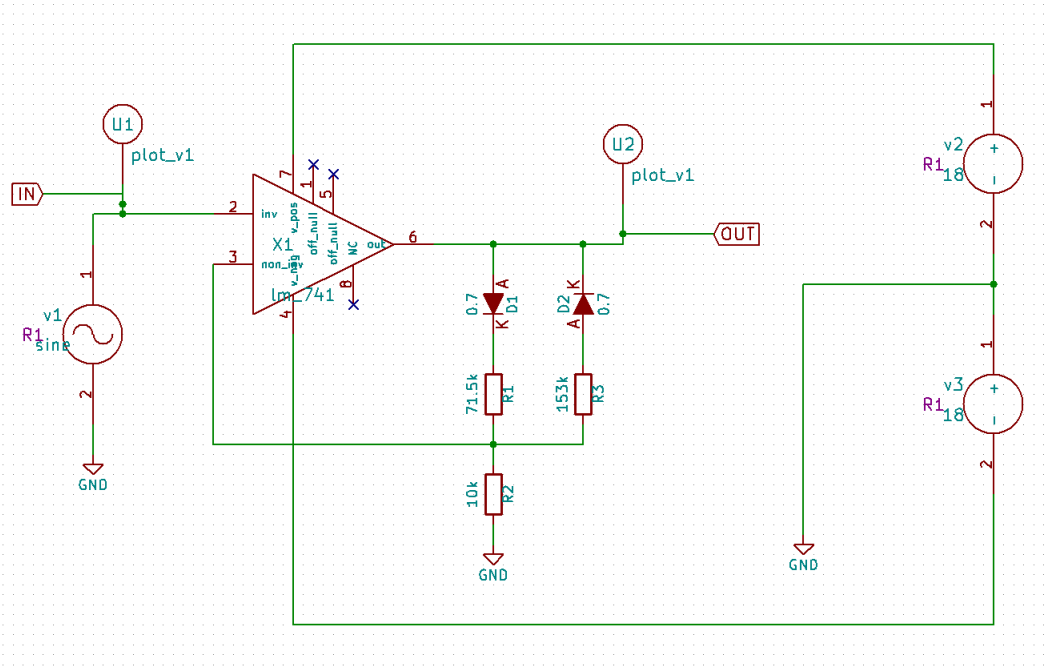

Figure 2: Schematic Diagram of Inverting Schmitt trigger circuit with diodes D1 and D2, UTP=2V &LTP=-1V.

Simulation Results:

The Simulation results of the Inverting Schmitt trigger circuit with diode D1 and UTP=6V, LTP=0V in eSim

1. Ngspice Plots

a. Inverting Schmitt trigger

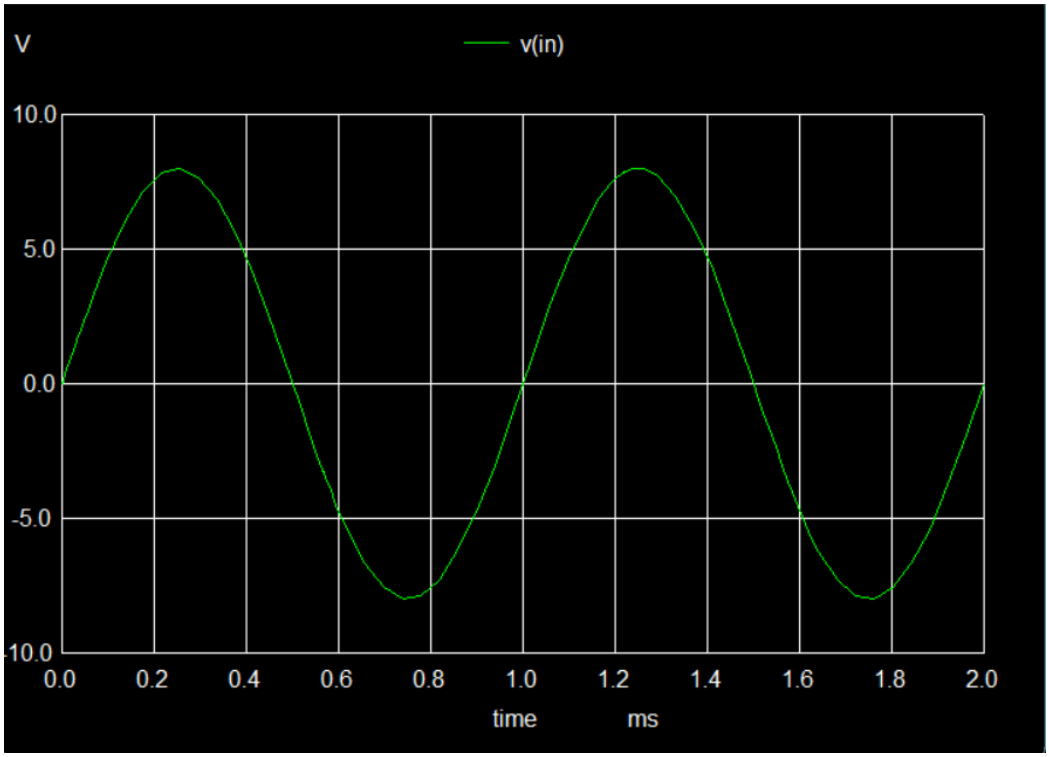

Figure 3: Ngspice Input Plot

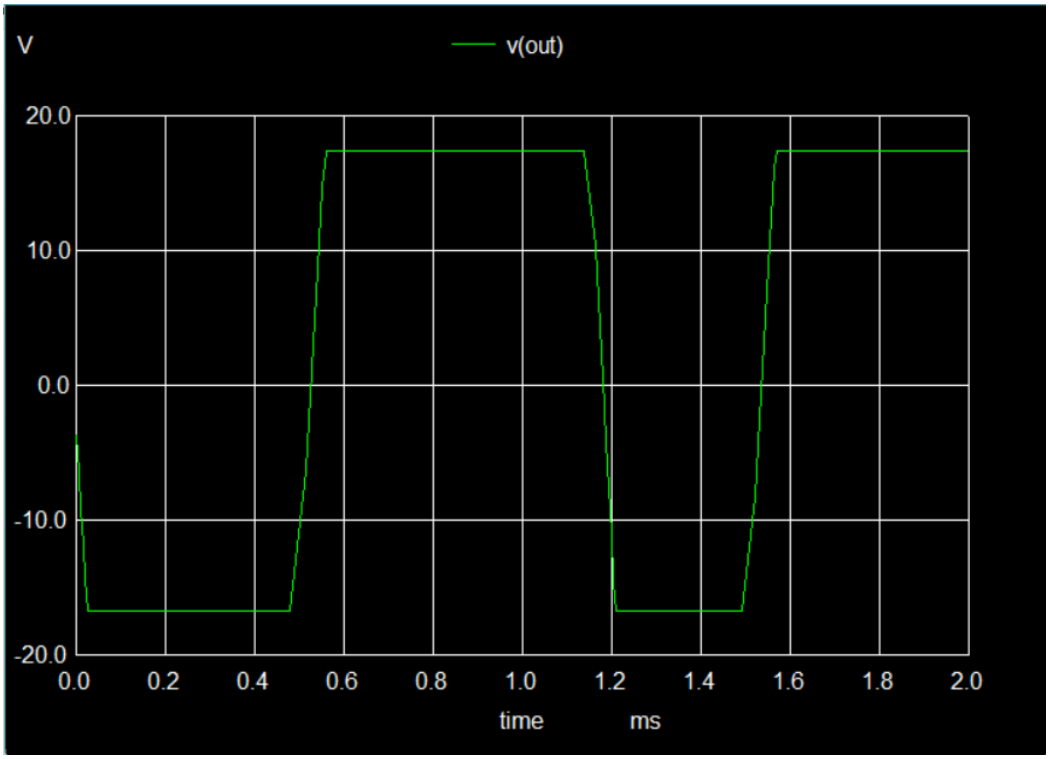

Figure 4: Ngspice Output Plot

1. Python Plots

a. Inverting Schmitt trigger

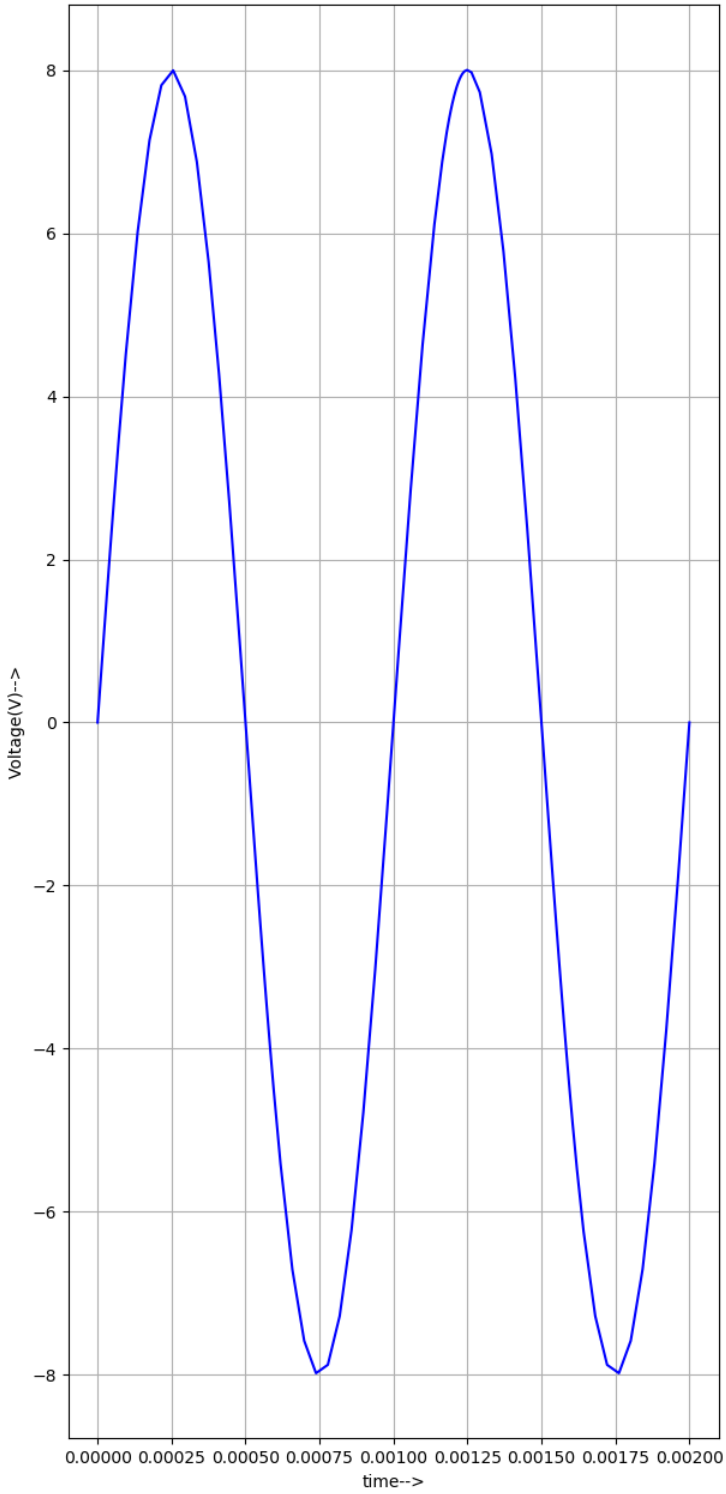

Figure 5: Python Plot Input

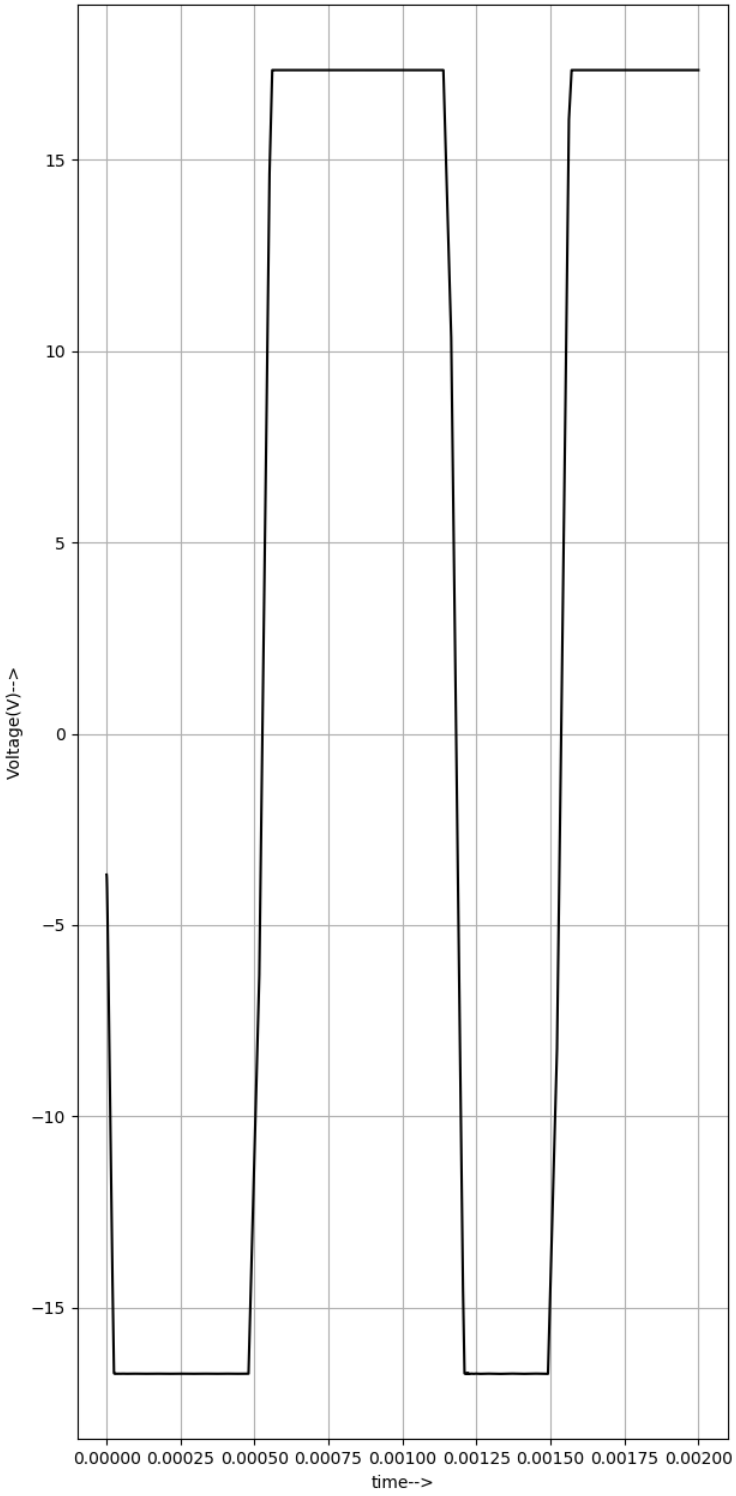

Figure 6: Python Plot Output

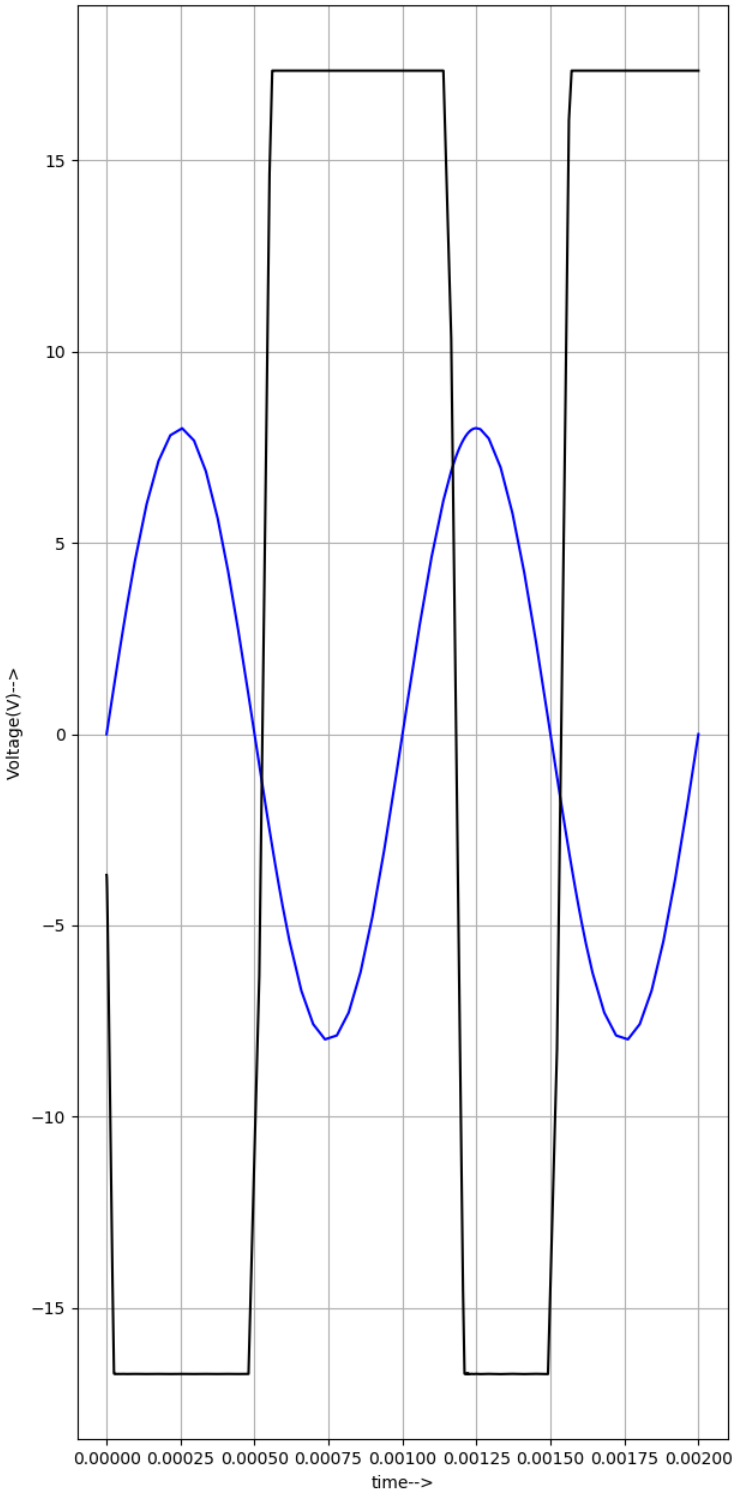

Figure 7: Python Plot Input & Output with UTP=6V, LTP=0V.

The Simulation results of the Inverting Schmitt trigger circuit with diodes D1 and D2, UTP=2V & LTP=-1V in eSim

2. Ngspice Plots

b. Inverting Schmitt trigger

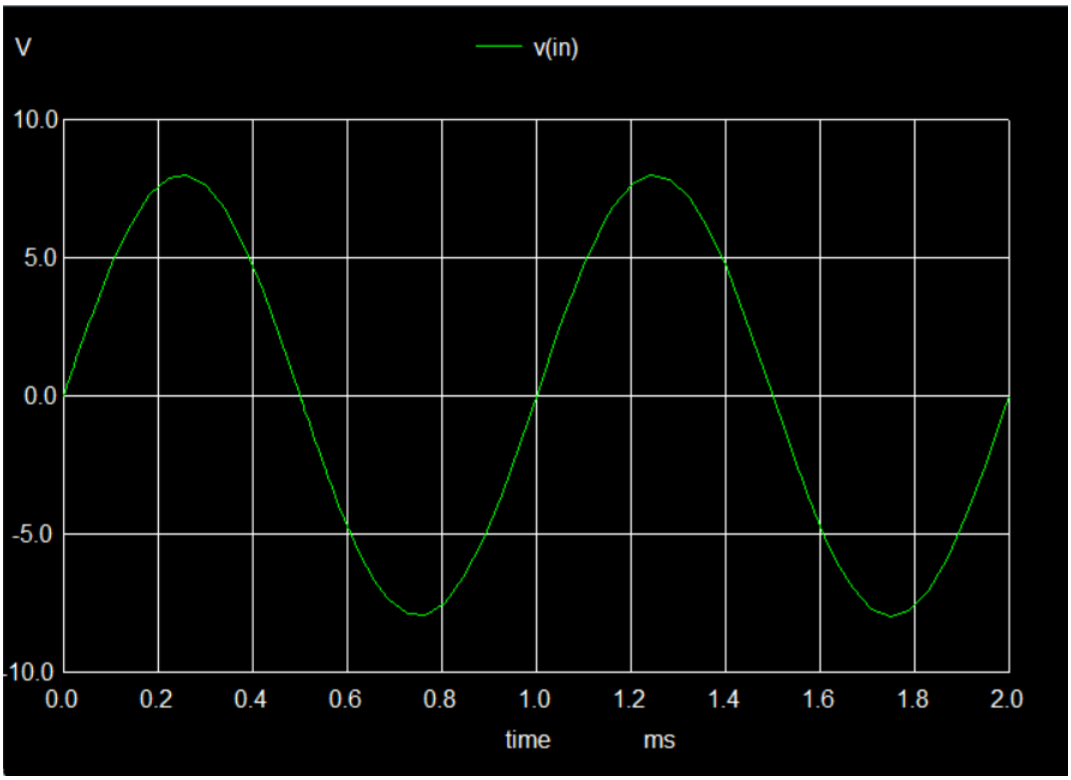

Figure 8: Ngspice Input Plot

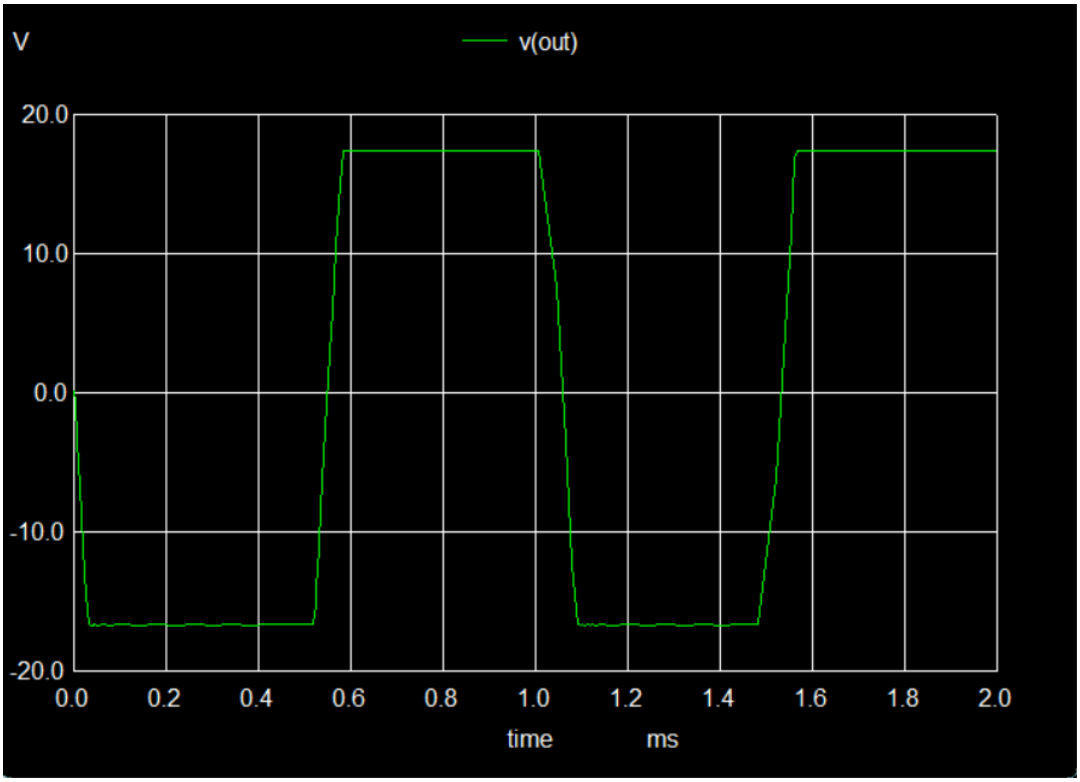

Figure 9: Ngspice Output Plot

3. Python Plots

b. Inverting Schmitt trigger

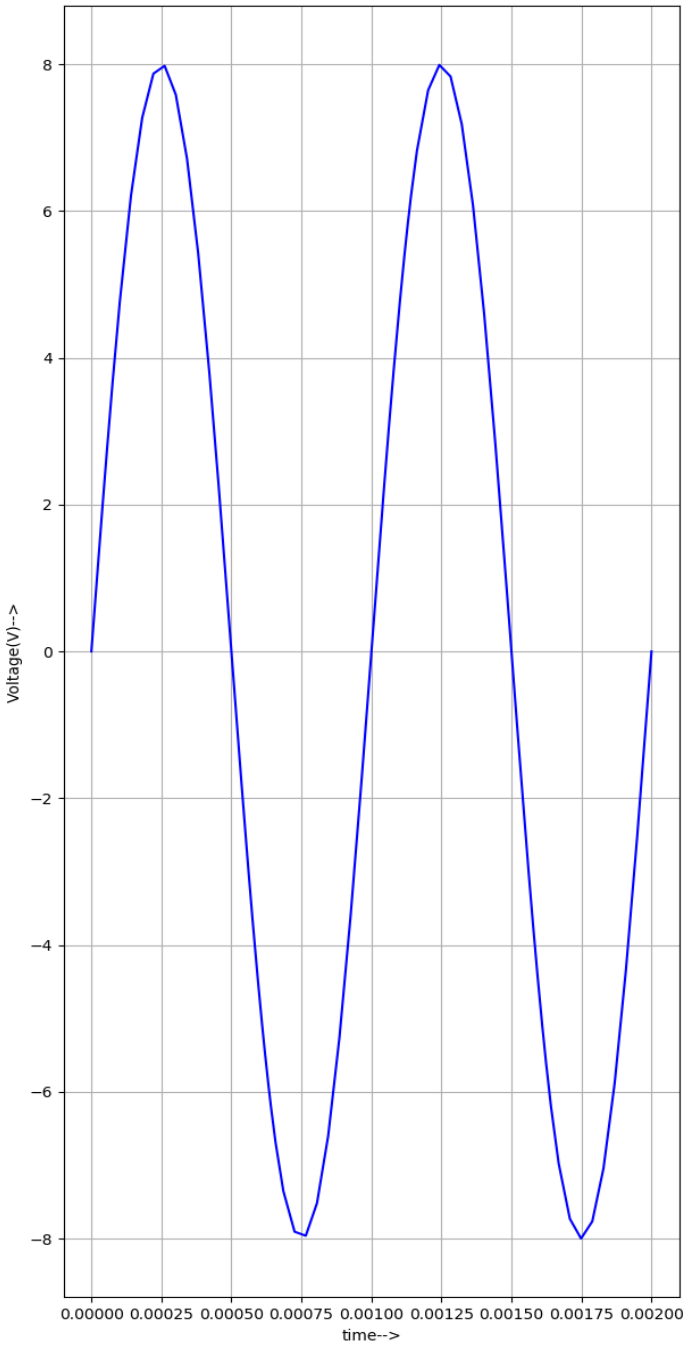

Figure 10: Python Plot Input

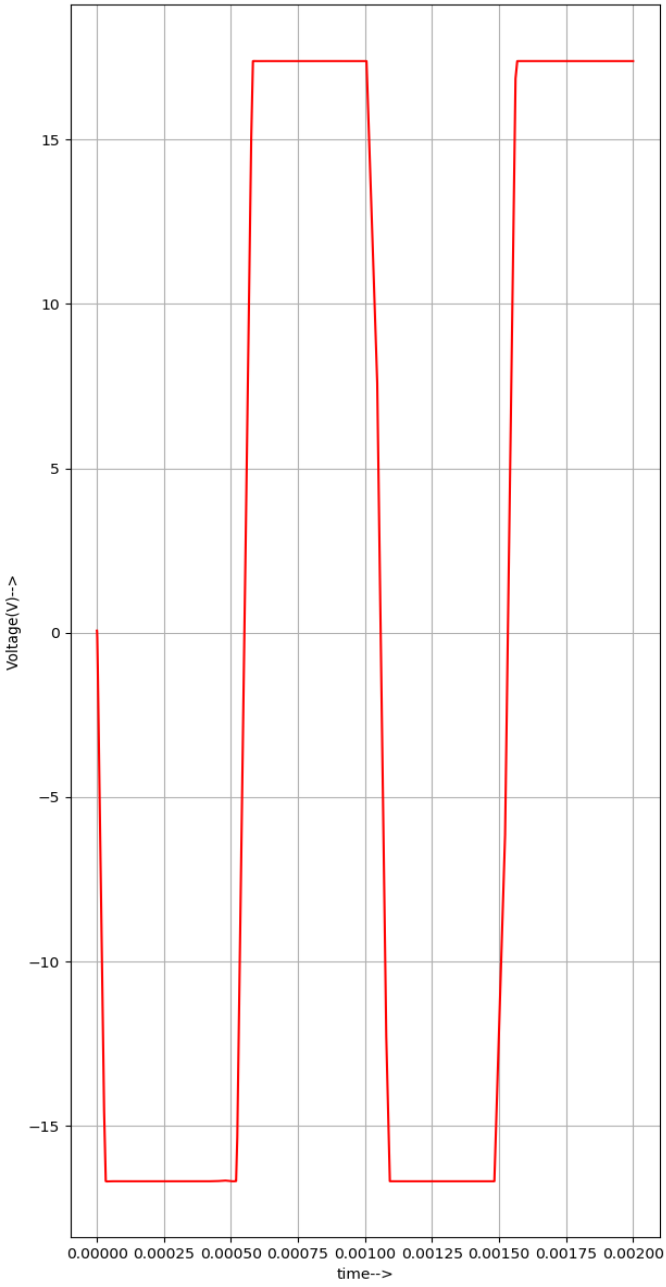

Figure 11: Python Plot Output

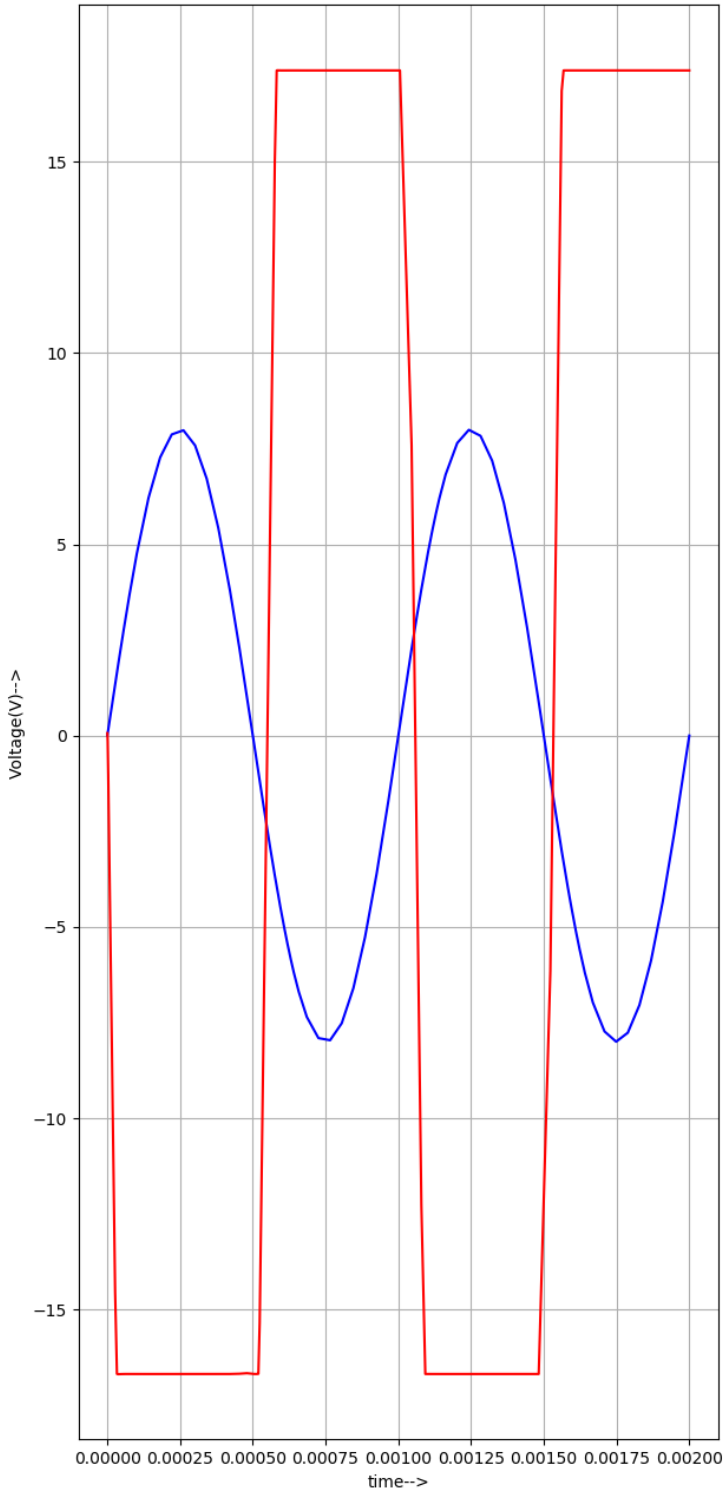

Figure 12: Python Plot Input & Output, UTP=2V &LTP=-1V.

Conclusion:

Inverting Schmitt trigger circuit using a single diode D1 and two diodes D1 and D2 with adjusted triggering points were simulated using eSim and appropriate waveforms were obtained.

References:

1. Electronic devices and circuits by David A Bell
2. https://www.electronics-tutorial.net/analog-integrated-circuits/schmitt-trigger/inverting-schmitt-trigger/