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Marks	

Experiment # 7

To understand Op-amp 741 IC and its application as Schmitt trigger

Objective:

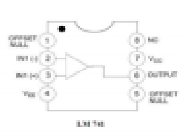
- *Schmitt trigger using Op-amp IC in Inverting mode*
- *Schmitt trigger using Op-amp IC in non- inverting mode*
- *Adjusting the trigger points*

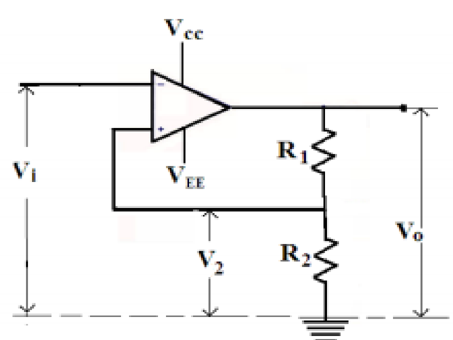
Apparatus:

Operational amplifier, bread board, jumpers, oscilloscope, probes

Theory:

Inverting Schmitt trigger: The IC Operational amplifier may be employed as a Schmitt trigger circuit, in inverting and non inverting mode. The design of such a circuit is quite simple. The input from the triggering voltage is applied to the inverting terminal. The non-inverting terminal is connected to the junction of R_1 and R_2 ; these resistor operate as the potential divider from output to ground. The voltage at the non inverting terminal is the voltage across R_2 as shown in the figure.





Inverting Schmitt trigger circuit

When the circuit is positively saturated, a positive voltage is feedback to the non-inverting input. This positive input holds the output in the high state. Similarly, when the output voltage is negatively saturated, a negative voltage is feedback to the non-inverting input, holding the output in the low state. In either case, the positive feedback reinforces the existing output state. Schmitt trigger is an assembly that gives output between two levels.

When a VIN of operational amplifier is less than V2 then non inverting output voltage is almost VCC.

VO= VCC-1 and V2= [R2 *(VCC - 1)] / (R2 + R1)

And the upper trigger point is the quality applied in the non-inverting terminal, that is

UTP = [R2 *(VCC - 1)] / (R2 + R1)

When input voltage rises than UTP, output becomes almost -VEE

VO = -VEE +1 and V2= [R2 (-VEE + 1)] / (R2 + R1)

And lower trigger point becomes equal to the V2, which is a negative quantity

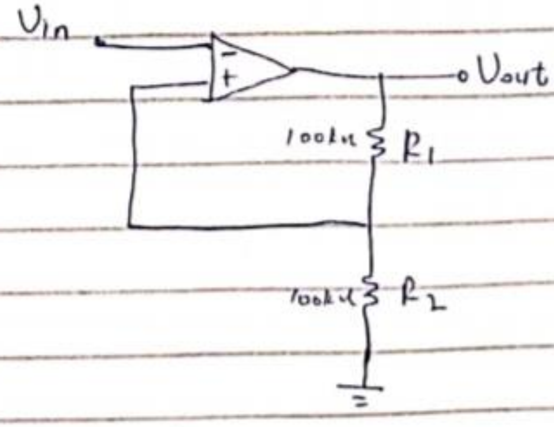
LTP = [R2 (-VEE + 1)] / (R2 + R1)

It is seen that UTP and LTP are equal in magnitude but opposite polarity

Designing:

Refer to example 13-2 in Floyd book.

Calculations:



$$V_{(UTP)} = \frac{R_2}{R_1 + R_2}\left(+V_{out(max)}\right)$$

$$= \frac{100k\Omega}{100k\Omega + 100k\Omega}(5)$$

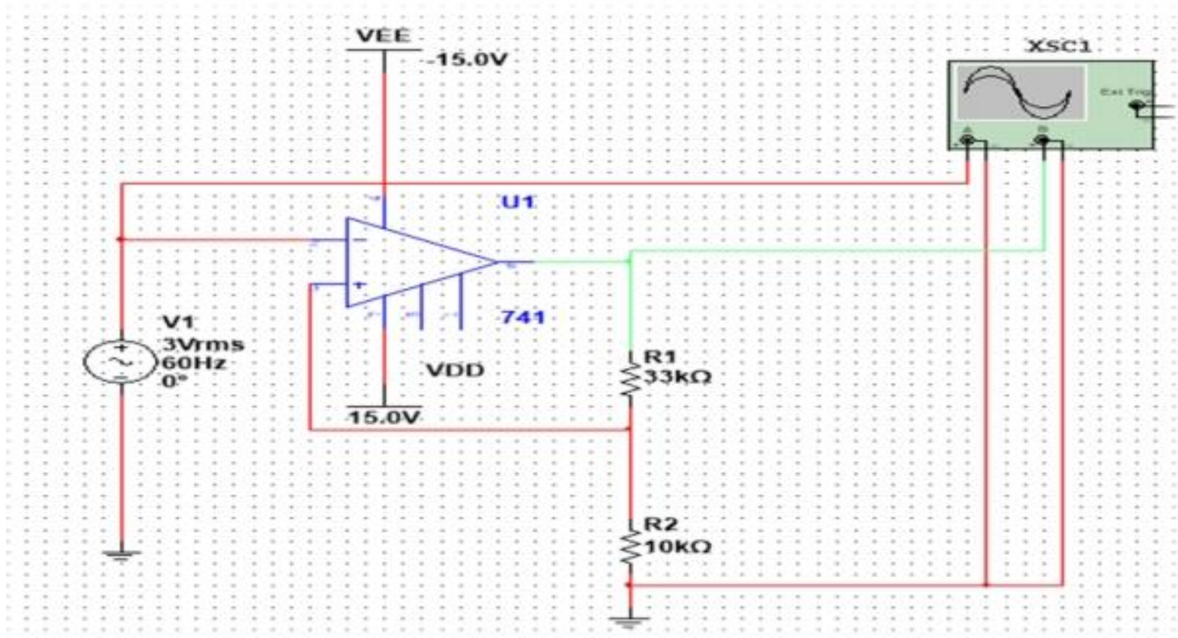
$$V_{(UTP)} = +2.5\,V$$

$$V_{LTP} = \frac{R_2}{R_1 + R_2}\left(-V_{out}\right)$$

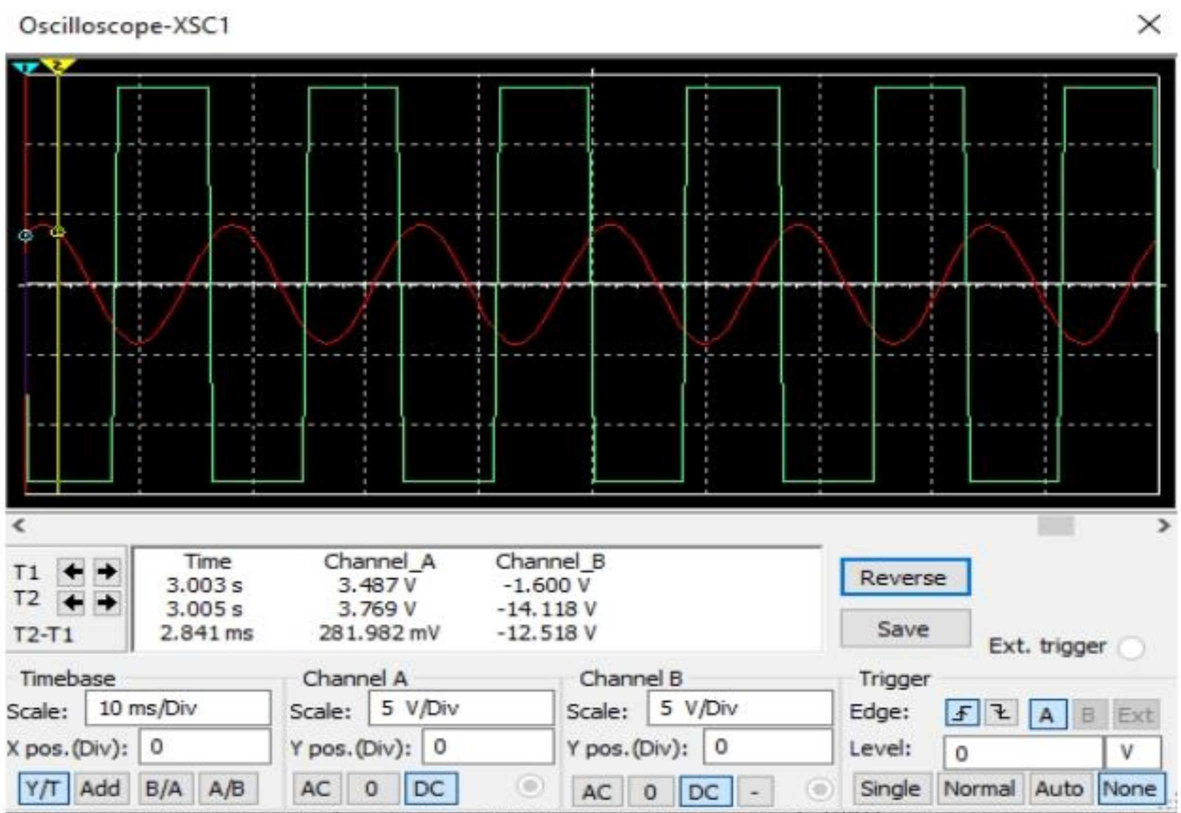
$$V_{LTP} = \frac{100\,k\Omega}{100k\Omega + 100\,k\Omega}(-5)$$

$$V_{LTP} = -2.5V$$

Circuit (inverting);

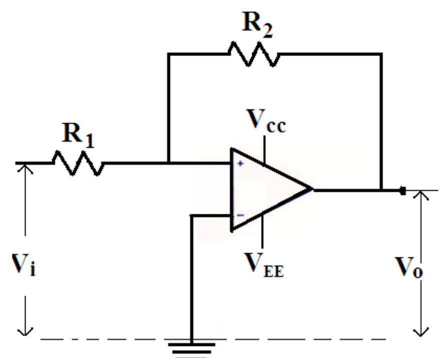


Input and Output Waveforms (INVERTING)



Non-Inverting Schmitt trigger:

The Op amp may also be employed as a Schmitt trigger circuit, in non-inverting mode. In this mode, the input voltage is applied to the non-inverting terminal through R1 resistor and R2 is connected between output and non-inverting terminal.



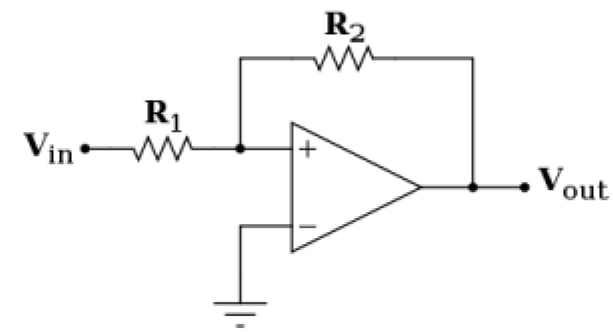
Non- Inverting Schmitt trigger circuit

This means that the circuit output goes positive when the Vi in increased from the UTP, and goes negative when the Vi is lowered than LTP level. Assume that the output is at negative saturation level (-VEE + 1). If the input is zero, then the voltage across R1 is

VR1 = [R1 (-VEE + 1)] / (R2 + R1)

So the voltage at the non-inverting terminal is a negative quantity. And this keeps the output to negative saturation level. The inverting terminal is grounded. For the output to go positive, Vi must be raised until the voltage at the non-inverting terminal is slightly above the inverting terminal level(i.e. Ground). The input level that makes the non-inverting terminal equal to inverting terminal voltage is UTP actually. After input reaching the UTP the output becomes positive saturation level (VCC-1). Similarly LTP is numerically equal to the UTP but with reverse polarity.

***Designing**:*
Referring figure below, calculate upper and lower trigger points.
Circuit;



R_2=100kΩ, R_1=10kΩ, Assume $V_{out(max)} = \pm 5V$

Calculations:

Non- Inverting Calculations:

$$V_{(UTP)} = \frac{-R_1}{R_2}\,(V_{out})$$

$$= \frac{-10\cancel{0}\,k\Omega}{100k\Omega}\,(5)$$

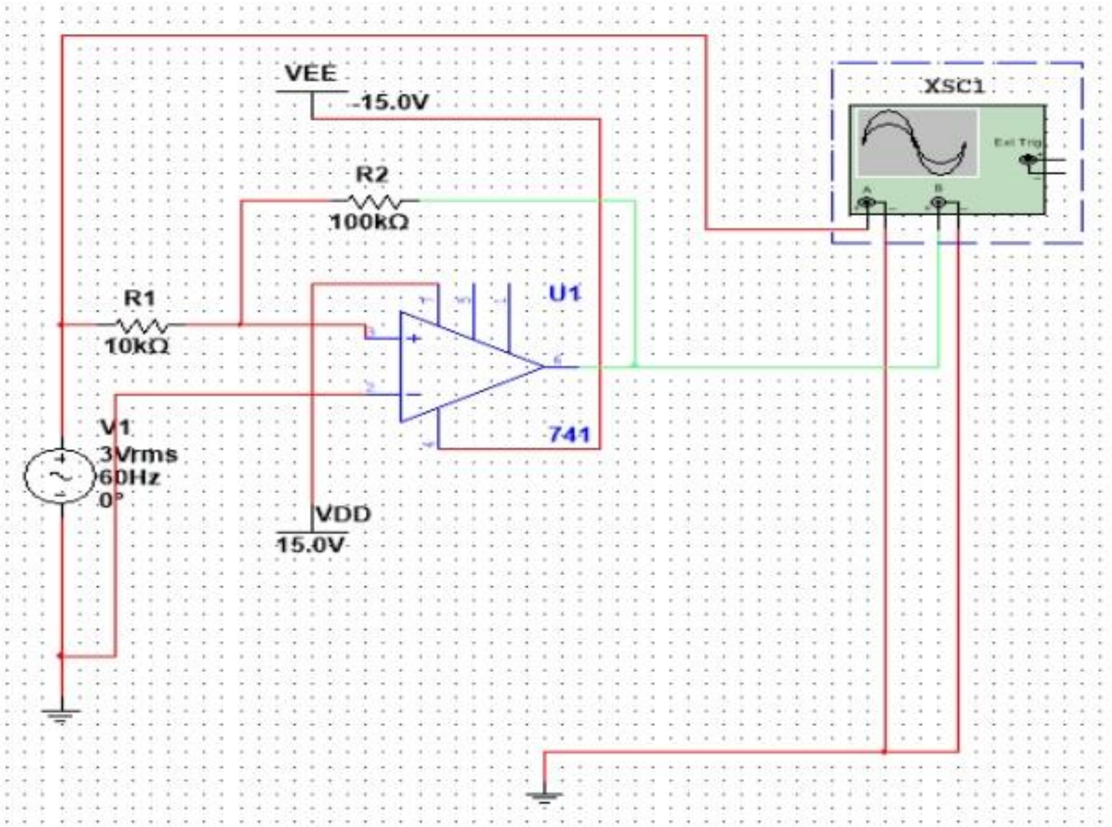
$$V(UTP) = -0.5V$$

$$V_{(LTP)} = \frac{-R_1}{R_2}\,(-V_{out})$$

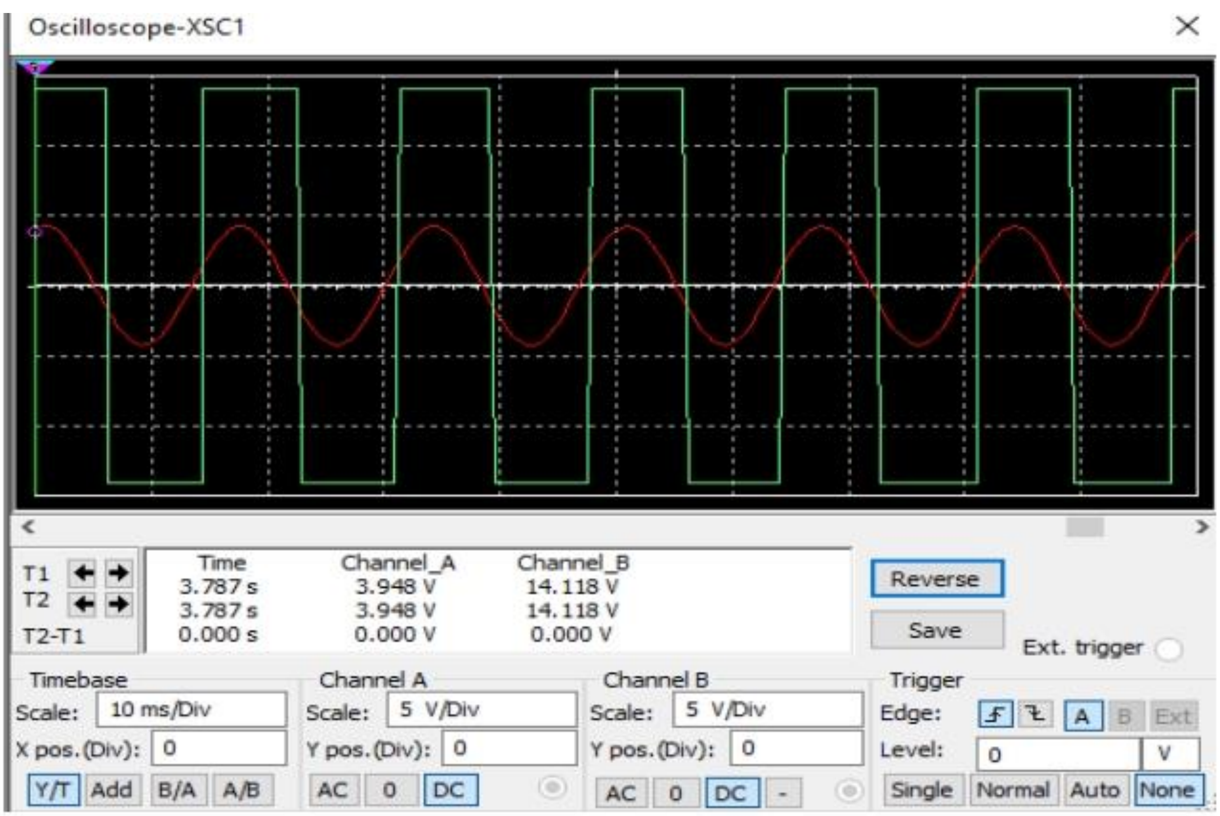
$$V(LTP) = \frac{-10k}{100k}\,(-5)$$

$$V_{(LTP)} = 0.5V$$

Circuit (non inverting);



Input and Output Waveforms: (NON-INVERTING)



Questions:

- **What is *Slew rate*? What is the maximum operating frequency of the op-amp?**
  Slew rate is defined as the maximum rate of change of an op amp's output voltage and is given units of volts per microsecond
  The maximum frequency at which an op-amp may operate depends on the slew rate bandwidth and unity gain bandwidth.
- **In inverting mode, How can we make LTP close to ground while UTP is remains same?**
  UTP stands for upper trigger point, whereas LTP stands for the lower trigger point. Hysteresis can be defined as when the input is higher than a certain chosen threshold (UTP), the output is low. When the input is below a threshold (LTP), the output is high; when the input is between the two, the output retains its current value. This dual threshold action is called hysteresis**.**

- **What happens if the threshold voltages are made longer than the noise voltages in schmitt trigger?**
  In schmitt trigger, if the threshold voltage VUT and VLT are made larger than the input noise voltage. The positive feedback will eliminate the false output transition.