ANALOG ELECTRONIC

ULTRA CONCURRENT REMOTE LAB

Contents:

Objectives:

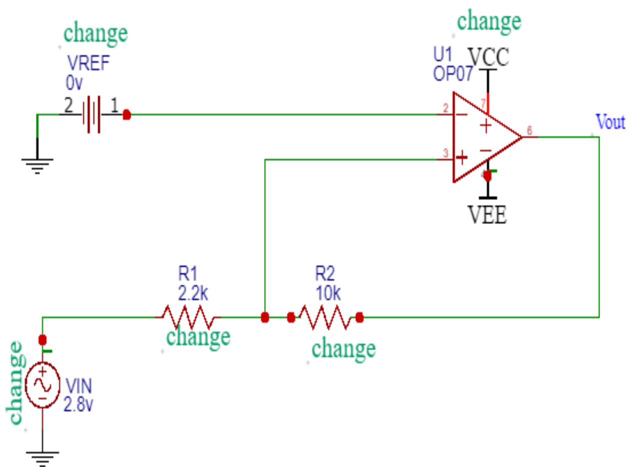
1. Perform frequency response of the circuit and observe the transfer characteristic.

2. Perform parametric variations and observe the impact of the same on the circuit response.

3. Verify the output response with the expected values.

4. Analyze the impact of each parametric variation on the circuit.

Circuit diagram



Design equations

$$V+ = \frac{V_O R_1}{R_1+R_2} + \frac{V_{REF} R_2}{R_1+R_2}$$

$V- = V_{REF}$,

When $V_o = +V_{SAT}$, $V+ = \frac{V_{SAT} R_1}{R_1+R_2} + \frac{V_{IN} R_2}{R_1+R_2}$

Vo will change from $+V_{SAT}$ to $-V_{SAT}$, when V_{IN} will just goes below V_{TL}, This will happen when $V+ < V-$ i.e. $V+ < V_{REF}$.

$$V_{TL} = -V_{SAT}\frac{R_1}{R_2} + V_{REF}\left(1+\frac{R_1}{R_2}\right)$$

When $V_o = -V_{SAT}$, $V+ = -\frac{V_{SAT} R_1}{R_1+R_2} + \frac{V_{IN} R_2}{R_1+R_2}$

Vo will change from $-V_{SAT}$ to $+V_{SAT}$, when V_{IN} will just goes exceeds V_{TH}, This will happen when

$V+ > V-$ i.e. $V+ > V_{REF}$.

Substituting $V+ = V_{REF}$, and $V_{IN} = V_{TH}$.

$$V_{TH} = +V_{SAT}\frac{R_1}{R_2} + V_{REF}\left(1+\frac{R_1}{R_2}\right)$$

Hysteresis voltage = $V_{TH} - V_{TL}$

$$V\ \text{Hysteresis} = 2V_{SAT}\frac{R_1}{R_2}$$

$$V_{TH} + V_{TL} = 2\, V_{REF}\left(1+\frac{R_1}{R_2}\right)$$

The Non-Inverting Schmitt Trigger in Ultra concurrent Laboratory has option to vary many circuit components and signal parameters and is listed in the Table 1. Fig.1 shows the schematic of Non-Inverting Schmitt Trigger with variable parameters. The signal frequency is fixed at 100 HZ to obtain the frequency response of the op-amp. However, to realize the frequency response of the Schmitt trigger the input signal frequency is swept from 100 HZ to 10 MHZ

TABLE: 1

Parameter	Variations
R_1	2.2 kΩ ,4.7 kΩ
R_2	5.6 kΩ, 10 kΩ
Vin	5V, 4V
Op-amp	#1, #2, #3

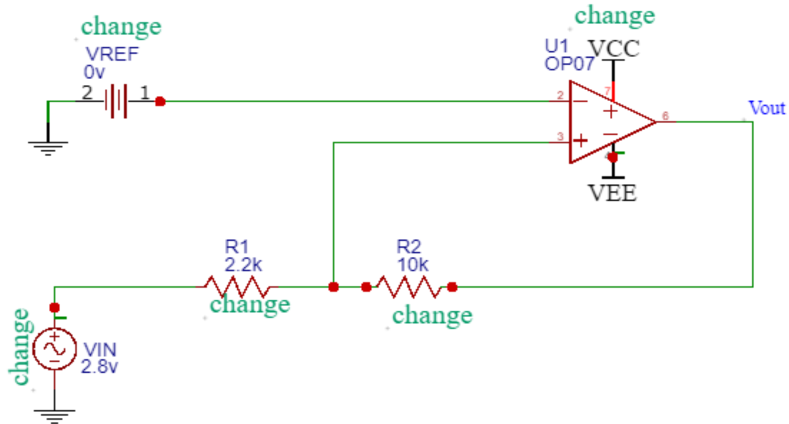


Fig. 1: Schematic of Non-Inverting Schmitt Trigger with variable options

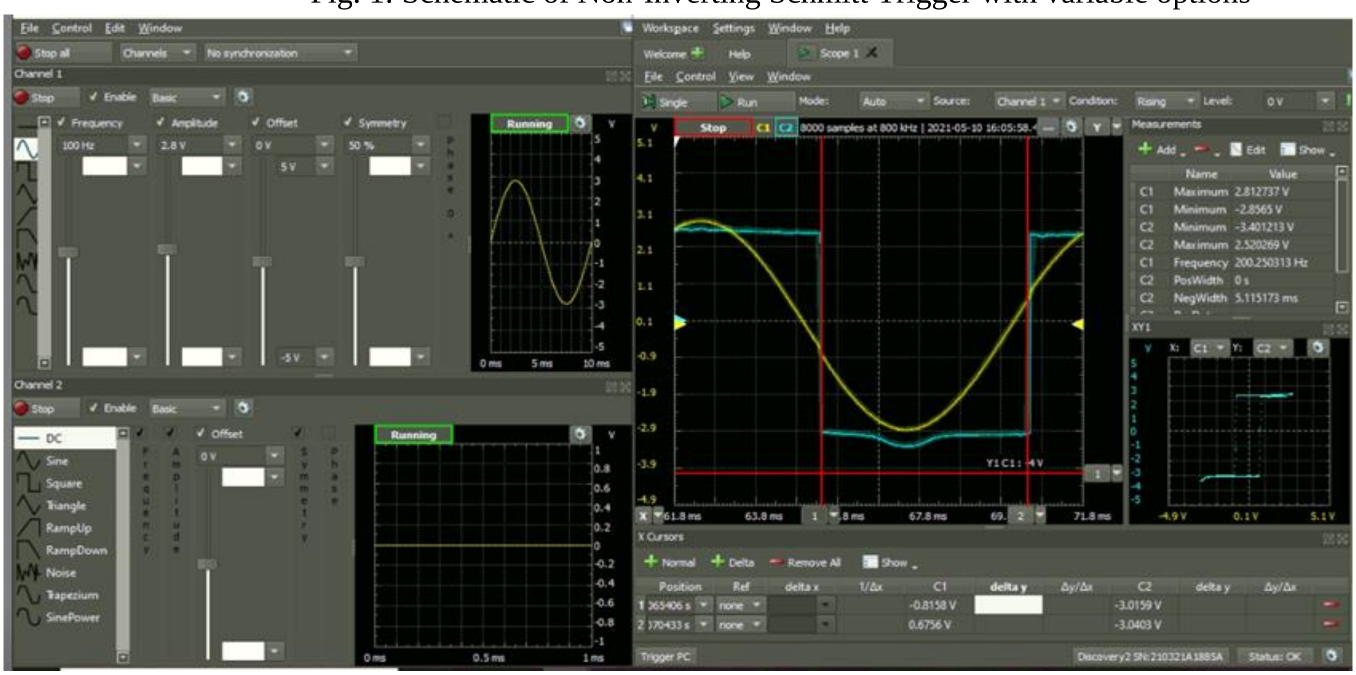


Fig. 2: Various view of the Non-Inverting Schmitt Trigger output responses

The laboratory has three important views to give real-time feeling during the conduction of the experiment. Fig.1 shows the circuit view and parameters to be changed.Fig.2 shows the scope of the waveform application that has input sine wave, dc voltage, frequency, amplitude, offset voltage, output response and transfer characteristics.

1. Effect of parametric variations on the circuit performances

As there are many variations are possible in the Non-Inverting Schmitt Trigger circuit, let's see the impact of each one on the circuit performance in detail.

1. Impact of reference voltage (V_{REF}) on the Inverting Schmitt Trigger Circuit:

In the Non-Inverting Schmitt trigger schematic it is possible to modify the value of V_{REF} voltage.

From the set of design equations shown above it can be verified that as $V_{REF}\uparrow \longrightarrow$

$V_{TH} \uparrow \longrightarrow V_{TL}\downarrow \longrightarrow R1\uparrow \longrightarrow R2\uparrow$.

If reference voltage and the value of resistors increases the value of threshold voltage also increases.

In order to verify the effect of reference voltage change the DC voltage to 1v. We can notice the shift in the threshold voltages (V_{TH} and V_{TL}). We have two threshold voltages i.e. Higher Threshold Voltage V_{TH} and Lower Threshold Voltage V_{TL} which is given by ,

$$V_{TH} = +V_{SAT} \frac{R1}{R2} + V_{REF} \left(1 + \frac{R1}{R2}\right)$$
$$V_{TL} = -V_{SAT} \frac{R1}{R2} + V_{REF} \left(1 + \frac{R1}{R2}\right)$$

TABLE: 2

V_{REF}	VTH	VTL	R_1 kΩ	R_2 kΩ	F Hz	V Hysteresis
0.72v	1.42v	-0.218v	2.2 kΩ	10 kΩ	100	1.638v
0v	1.9v	-1.176v	2.2 kΩ	5.6 kΩ	130	3.076v
-0.72v	0.2v	-2.5v	4.7 kΩ	10 kΩ	150	2.7v
0.01	2.07v	-2.6v	4.7 kΩ	5.6 kΩ	200	4.67v
Remarks	Evaluation	Evaluation	Specification	Specification	Almost constant	

Various output parameters of the CE amplifier circuit noted from the different views for the changes in V_{REF} are recorded and tabulated in TABLE: 2

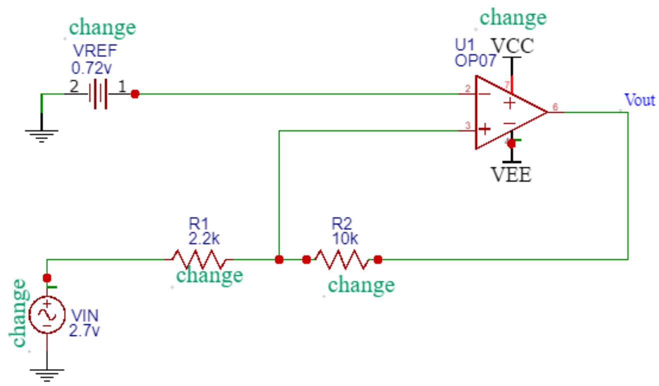


Fig. 3.View of Non-Inverting Schmitt Trigger circuit for variation in V_{REF} value

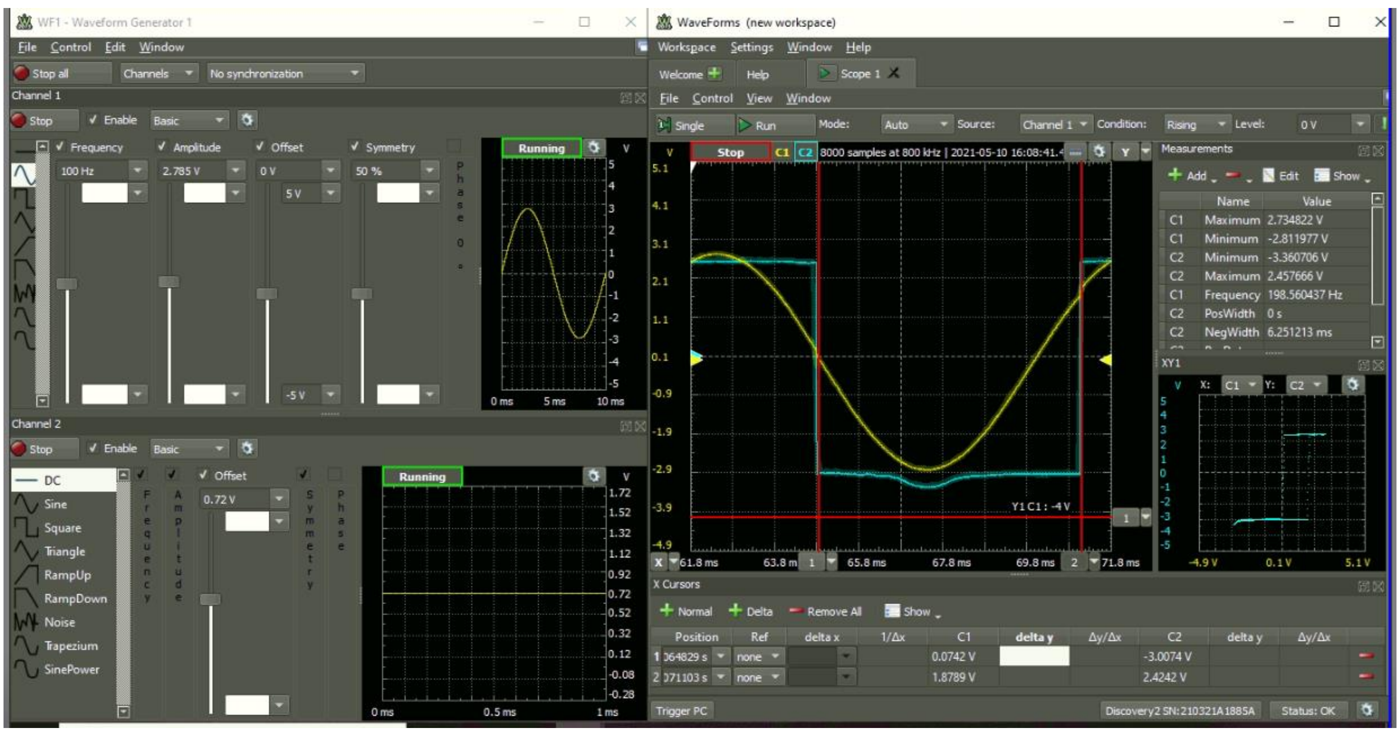


Fig. 4. View of Non-Inverting Schmitt Trigger responses for variation in V_{REF} value

Similar analysis is done by changing the choosing different combinations of constant parameter of V_{IN}.

2. Impact of R_1 on the Inverting Schmitt Trigger:

In the Non-Inverting Schmitt Trigger schematic it is possible to modify the value of R_1 from 2.2 kΩ to 4.7 kΩ. To understand the effect of change in resistor R1. Observe the change in the threshold voltages as per the new value of resistor R1.From the set of design equations shown above it can be verified that as R1 ↑ $\longrightarrow$ Threshold voltage ↑ . Various output parameters of the Inverting Schmitt Trigger Circuit noted from the different views for the changes in R_1 are recorded and tabulated in TABLE: 3

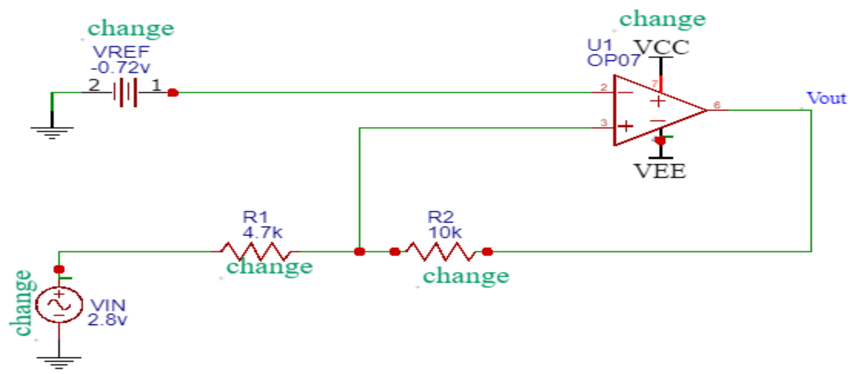


Fig.5.View of Non-Inverting Schmitt Trigger circuit for variation in R_1 value

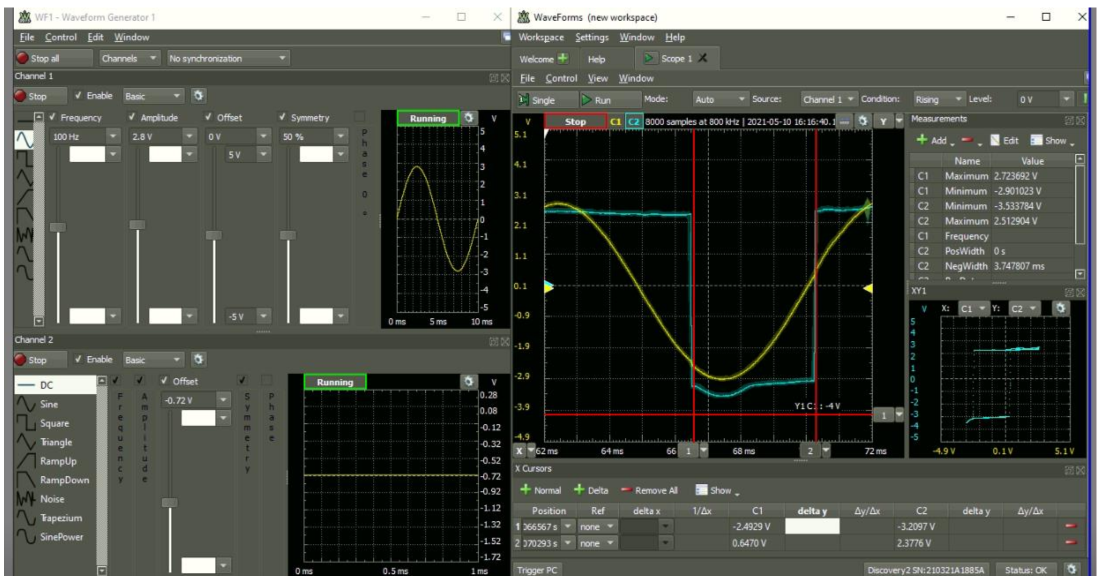


Fig.6.View of Non-Inverting Schmitt Trigger responses for variation in R_1 value

TABLE: 3

R_1 kΩ	V_{REF}	V_{TH}	V_{TL}	F Hz	V Hysteresis
4.7 kΩ	-0.72v	-0.2v	-2.5v	100	2.3v
2.2 kΩ	0.72v	1.42v	-2.18v	160	3.6v
4.7 kΩ	0v	1.22v	-1.504v	100	2.724v
2.2 kΩ	-1.29v	1.023v	-2.23v	120	3.253v
Remarks		Evaluation	Evaluation		

Note: R_2 = 10kΩ

Similar analysis is done by choosing different combinations of constant parameters of R_2 and V_{IN}.

3. Impact of R_2 on the Inverting Schmitt Trigger:

In the Non-Inverting Schmitt Trigger schematic it is possible to modify the value of R_2 from 10 k Ω to 5.6 k Ω. To understand the effect of change in resistor R_2. Observe the change in the threshold voltages as per the new value of resistor R_2.

From the set of design equations shown above it can be verified that as R2 ↑ ⟶

V_{REF}↑ ⟶ Threshold voltage↑ . If the value of R_2 and reference voltage is increased threshold voltage also increases .If R_2 increases and V_{REF} is kept constant threshold voltage decreases. When R1 is kept constant. If V_{REF} is kept constant the value of V_{TH} will get slightly changed.

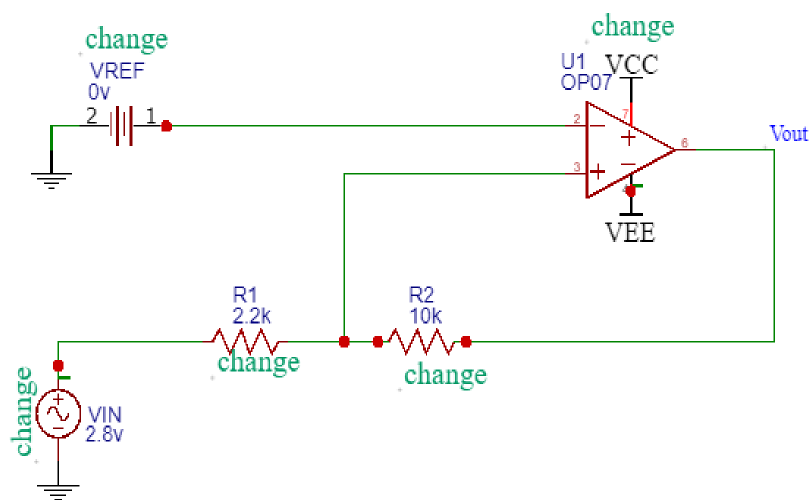


Fig.7.Views of Non-Inverting Schmitt Trigger circuit for variation in R_2 value

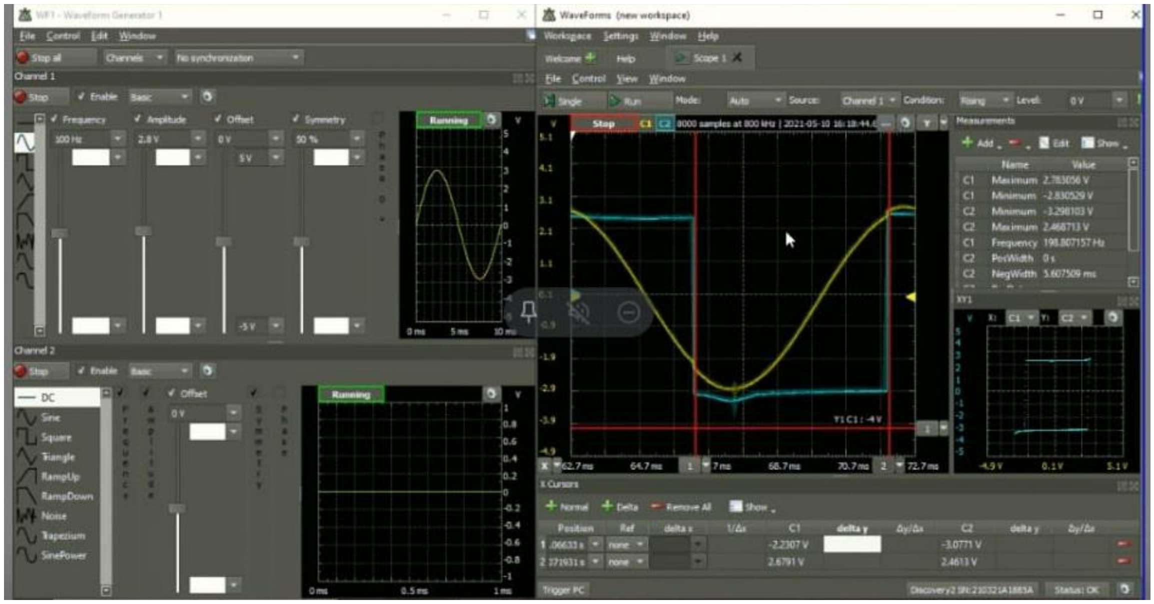


Fig.8.View of Non-Inverting Schmitt Trigger responses for variation in R_2 value

TABLE: 3

R_2 kΩ	V_{REF}	V_{TH}	V_{TL}	F Hz	V Hysteresis
10 kΩ	0v	0.55v	-0.66v	200	1.21v
5.6 kΩ	0.46v	1.54v	-0.53v	260	2.07v
10 kΩ	-0.72v	0.2v	-2.5v	150	2.7v
5.6 kΩ	-0.31v	1.52v	-3v	100	4.52v
Remarks		Evaluation	Evaluation		

Note: R_1 = 2.2 kΩ

Similar analysis is done by choosing different combinations of constant parameters of R_1, V_{IN}.

4. Impact of V_{IN} on the Inverting Schmitt Trigger:

In the Non-Inverting Schmitt Trigger Schematic, it is possible to modify the value of V_{IN} from 2.8v to 3v.

To know the importance of amplitude of the input signal reduce the amplitude of the input sine wave. Notice the output either at $+V_{SAT}$ or $-V_{SAT}$.

Figure:6 shows the transfer characteristics of Non-Inverting Schmitt Trigger. As shown in the figure when the input voltage is greater than lower threshold voltage the output remains in $–V_{SAT}$. Then the input starts increasing in the positive direction .When input voltage crosses higher threshold voltage i.e. if input voltage is greater than V_{TH} there will be a transition from $–V_{SAT}$ to $+V_{SAT}$. Output remains in $+V_{SAT}$ as long as $V_{IN} > V_{TH}$. When input voltage goes less than threshold voltage output starts transition from $+V_{SAT}$ to $–V_{SAT}$. If input voltage increases more than threshold voltage again there will be a transition from $–V_{SAT}$ to $+V_{SAT}$.

TABLE: 4

Vin	VO
$>V_{TL}$	$+V_{CC}$
$<V_{TH}$	$-V_{CC}$
$>V_{TH}$	$+V_{CC}$

From the TABLE: 4, we can see the variation in the input voltage results in variation of output voltage by transition from $+V_{SAT}$ to $-V_{SAT}$ or from $-V_{SAT}$ to $+V_{SAT}$. Depending on whether the output voltage is $+V_{CC}$ or $-V_{CC}$ we will have voltage at non – inverting terminal (V+) , V_{TH},V_{TL}

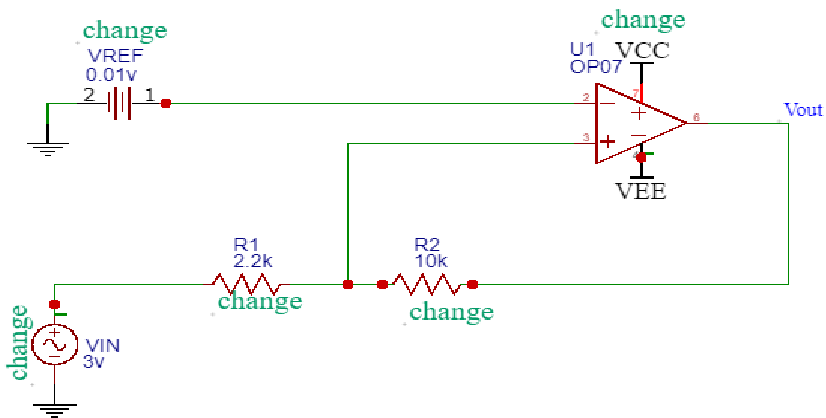


Fig.9.View of Non-Inverting Schmitt Trigger circuit for variation in V_{IN} value

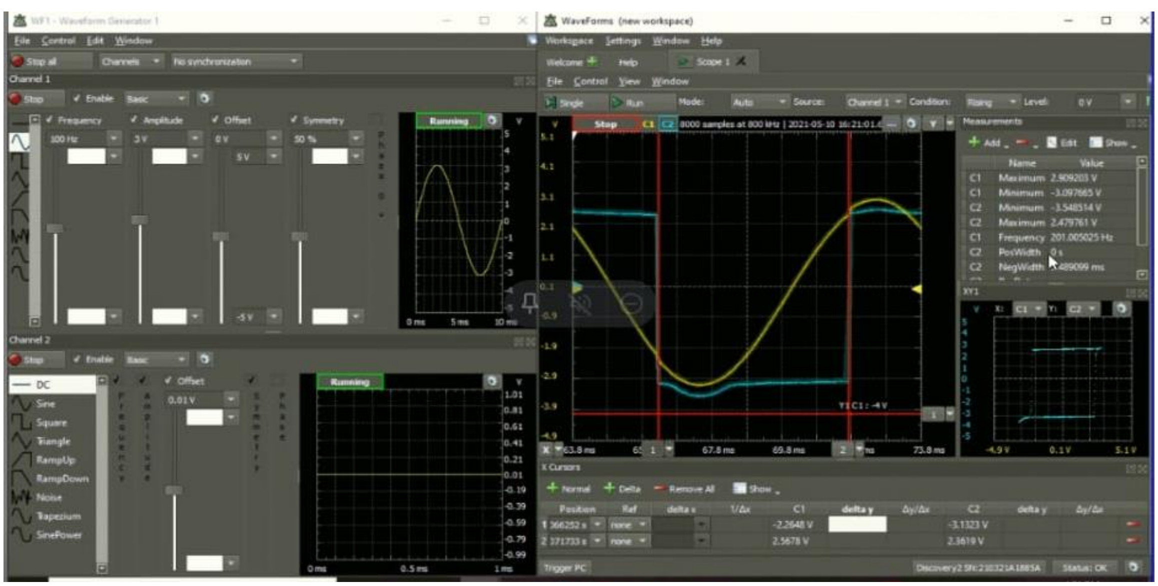


Fig. 10.View of Non-Inverting Schmitt Trigger responses for variation in V_{IN} value

In this experiment it is also possible to measure the slew rate of the op-amp. By observing slope of the output waveform.

Summary of the impact of components on the amplifier response

TABLE: 6

Circuit Response							
Parameter	R_1 kΩ	R_2 kΩ	$+V_{CC}$	$-V_{CC}$	V_{TH}	V_{TL}	V_{REF}
V_{REF}	✓	✓	✓	✓	✓	✓	✓
R_1	✓	X	X	X	✓	✓	✓
R_2	X	✓	✓	✓	✓	✓	✓
V_{IN}	X	X	✓	✓	✓	✓	✓

✓ **Impact** X **No impact** Tabular column in the

TABLE:6 is used to record various output response for different variation can be entered for further analysis. Op-amp LT1012D, Vin=5v

TABLE: 7

Sl. No.	R_1 kΩ	R_2 kΩ	V_{REF}	V_{TH}	V_{TL}	V Hysteresis	V_{TH}(measured)	V_{TL}(measured)
1.	2.2k	10k	0v	0.55v	-0.66v	1.21v		
2.	2.2k	10k	0.72v	1.42v	-0.218v	1.638v		
3.	2.2k	10k	-1.29v	1.023vv	-2.23v	3.253v		
4.	2.2k	5.6k	0v	1.9v	-1.176v	3.076v		
5.	2.2K	5.6k	0.46v	1.54v	-0.53v	2.07v		
6.	2.2k	5.6k	0.41v	1.472v	-0.7v	2.172v		
7.	4.7K	10k	0v	1.22v	-1.504v	2.724v		
8.	4.7k	10k	-0.72v	0.2v	-2.5v	2.7v		
9.	4.7k	5.6k	0 v	2.09v	-2.6009v	4.6909v		
10.	4.7k	5.6k	0.01v	2.07v	-2.6v	4.67v		
11.	4.7K	5.6k	-0.31v	1.52v	-3v	4.52v		