



# Cinch and Sterling Analog Circuits for Laboratory

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**ABSTRACT:** As we know that there is ever increasing demand for compact circuits and less complex wirings over the board, a technological boon evolved for such demand is Printed Circuit Board (PCB). A PCB will mechanically supports and electrically connects electronic components using conductive tracks, pads. These boards will have minimal chances for short circuits, components on the board are fixed; another advantage is creation of multiple boards using single design. Taking this technology forward to our everyday life, we implemented analog communication laboratory circuit, Schmitt trigger.

**KEYWORDS:** Printed circuit board (PCB), Analog circuit, Schmitt trigger, laboratory kit.

## I.INTRODUCTION

It is very difficult to rig up the circuit every now and then, which is time consuming and while doing this we might miss some connection or there are chances of loose connections. Apart from all these cumbersome processes there are chances of short circuiting due to lots of wire on single small breadboard. All these problems can be solved by developing Printed Circuit Board for all the laboratory experiments that are carried out. This project was carried out to demonstrate how PCB technique can used to solve the problems faced in our day-to-day life in our college laboratory. To demonstrate this idea we have developed a Kit for one of our AC+LIC lab experiments that is Schmitt trigger circuit.

A Schmitt trigger is a comparator circuit that incorporates positive feedback. When the input is higher than a certain chosen threshold, the output is high; when the input is below another (lower) chosen threshold, the output is low; when the input is between the two, the output retains its value. The trigger is so named because the output retains its value until the input changes sufficiently to trigger a change. This dual threshold action is called hysteresis, and implies that the Schmitt trigger in circuit diagrams is a triangle with a hysteresis symbol. The Schmitt trigger is a comparator application which switches the output negative when the input passes upward through a positive reference voltage. It then uses negative feedback to prevent switching back to the other state until the input passes through a lower threshold voltage, thus stabilizing the switching against rapid triggering by noise as it passes the trigger point.

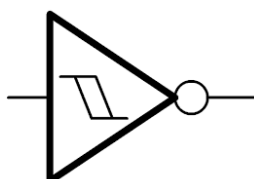


Figure 1: Symbol for Schmitt trigger

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Figure 2 shows an inverting comparator with feedback. This circuit converts a sine wave or any irregular shaped wave in to a square wave or pulse. This circuit is known as the Schmitt trigger or squaring circuit.

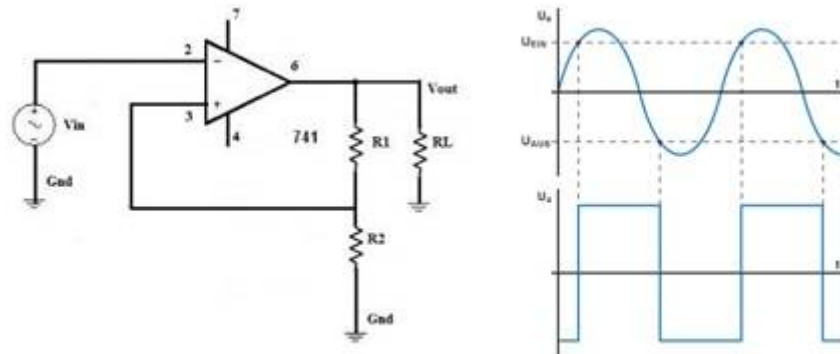


Figure 2: Circuit diagram of inverting comparator and its output

## II. OPERATION

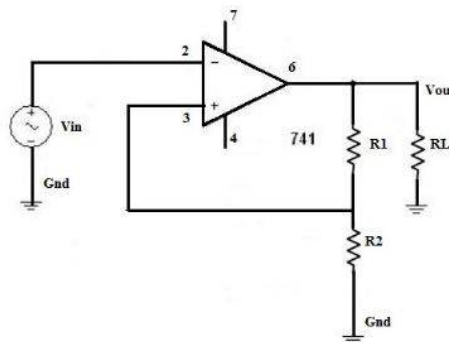


Figure 3: Schmitt trigger with no reference

Above figure 3 shows the positive feedback comparator with signal applied at the inverting terminal of the op-amp. The input voltage  $V_{in}$  triggers the output voltage  $V_{out}$  every time it exceeds certain voltage levels called the upper threshold voltage  $V_{UTP}$  and the lower threshold voltage  $V_{LTP}$ . These threshold voltages are derived using potential divider  $R_1$ - $R_2$ . The voltage across  $R_1$  is fed back to the non-inverting terminal of the op-amp.

The voltage across  $R_1$  depends on the value and polarity of the output voltage  $V_o$  when  $V_o = +V_{SAT}$ , the voltage across  $R_1$  is called the Upper Threshold voltage  $V_{UTP}$  and is given as

$$V_{UTP} = \frac{R_1}{R_1 + R_2} * (+V_{sat})$$

On the other hand, when  $V_o = -V_{SAT}$ , the voltage across  $R_1$  is called the Lower Threshold voltage  $V_{LTP}$  and is given as

$$V_{LTP} = \frac{R_1}{R_1 + R_2} * (-V_{sat})$$

Schmitt trigger is a comparator circuit but inside it is a positive feedback what results in hysteresis and memory effect. Comparing to simple logical elements Schmitt triggers have two threshold levels. Between these threshold values  $U_1$  and  $U_2$  the state of the output doesn't change what is so called a hysteresis. Such effect stabilizes output against rapid triggering by noise. Below is two characteristics compared of simple logical inverter and Schmitt trigger inverter as indicated in figures 4(a) and 4(b).

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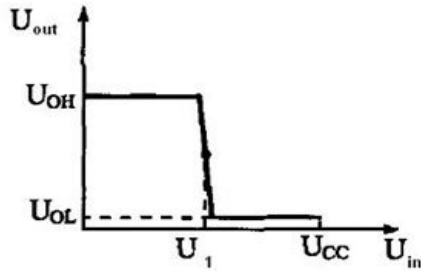


Figure 4: (a) Simple Inverter

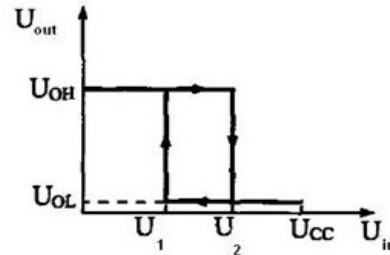


Figure 4: (b) Schmitt trigger inverter

We see that a Schmitt trigger characteristic is more complex, the output signal threshold depends on direction of input voltage rise/drop. When input signal is rising towards  $U_{max}$  then threshold is  $U_2$ , when input voltage is dropping towards zero threshold become  $U_1$ .

Let's see how this would look with real noisy signal.

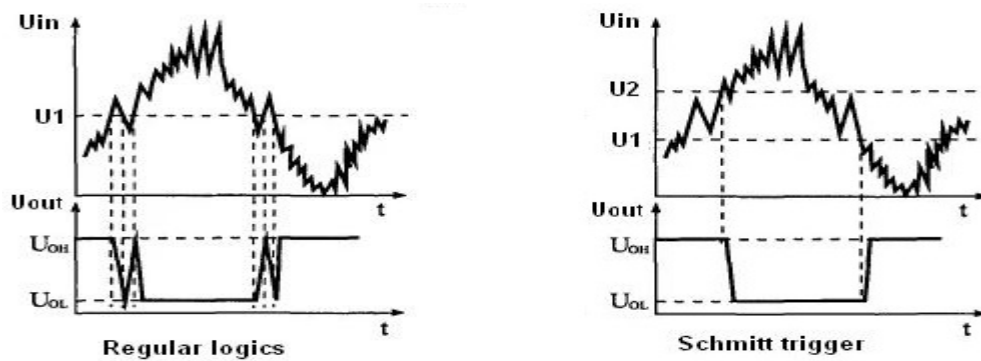


Figure 5: regular circuit Vs Schmitt trigger

Because of hysteresis any noise that amplitude is lower than  $U_2 - U_1$  is removed. And another fact, that signal front becomes square.

Standard digital chips has Schmitt trigger with same logical functions like TTL inverters, NAND. For TTL IC's thresholds are 0.9V ( $U_1$ ) and 1.7V ( $U_2$ ).

### III. CIRCUIT DIAGRAM

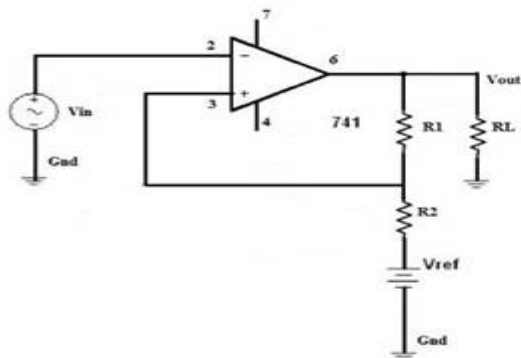


Figure 6: (a) Positive reference

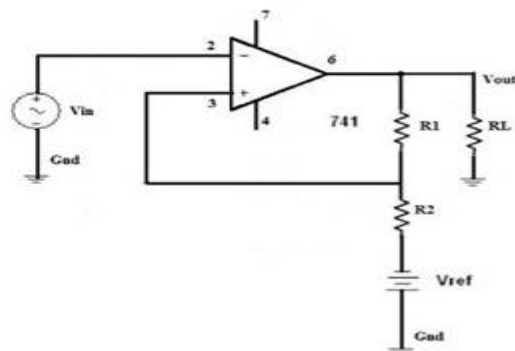


Figure 6: (b) Negative reference

Fig 6 (a) and Fig 6 (b) shows the circuit connections for positive reference and negative reference respectively. The output for which is shown in fig 7 (b) and fig 7 (c).

### IV. OUTPUT

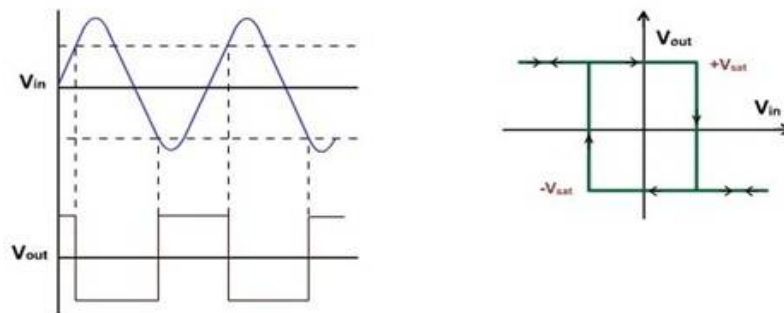


Figure 7 (a) No reference

Above fig 7 a. shows the output waveform of the circuit when there is no reference voltage or zero reference voltage. It also indicates the transfer characteristics of the circuit for given input values without reference voltage.

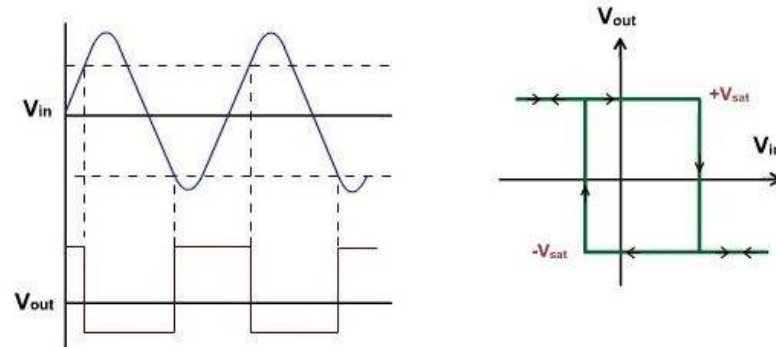


Figure 7 (b) Positive references

Above fig 7 b. shows the output waveform of the circuit when there is positive reference voltage. It also indicates the transfer characteristics of the circuit for given input values with positive reference voltage.

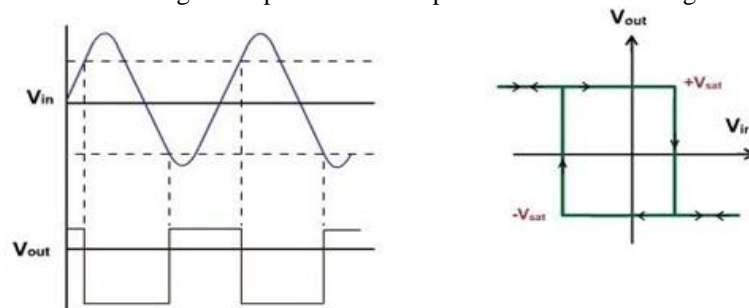


Figure 7 (c) Negative references

Above fig 7 c. shows the output waveform of the circuit when there is negative reference voltage. It also indicates the transfer characteristics of the circuit for given input values with negative reference voltage.

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## V. PROCEDURE TO DEVELOP A CUSTOMIZED PCB

- i. The first step to design the circuit using some available software. I have used **Express PCB** for developing the design for the Schmitt trigger circuit. Express PCB comes with component manager data base from which u can select the type of component you are going to place on your board. In software you can change the properties of the traces and pads as per your requirement. The next step is to take the print of this design on glossy paper using a laser printer. The method which I have used in making the PCB is called **tonner transfer** method.
- ii. Tools and Components required
  1. Iron box
  2. Driller
  3. Copper Clad(as per the size of the circuit)
  4. Etching solution( Ferric Chloride)
  5. Glossy paper
  6. Laser printer
  7. Marker Pen

## VI. KIT LAYOUT

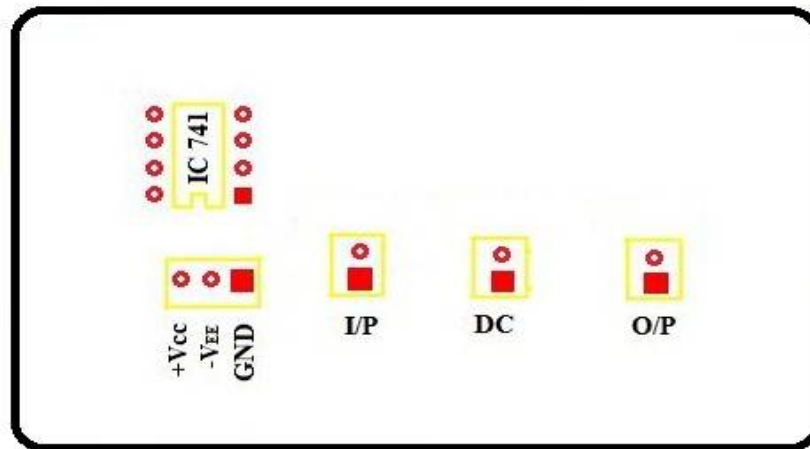


Figure 8: (a) Front end of the kit

Fig 8 a. Shows how front end of the kit, it is how the electronics components like IC 741, resistors, molex connectors are placed. It also indicates the input pins to give input to the IC as well as circuit, and from where the output is measured

### PIN DESCRIPTION OF KIT

+VCC	- Power supply (+12V)
-VEE	-Power supply (-12V)
GND [ ■ ]	-ground point for the circuit
I/P	-Input pin
DC	-Pin for giving the dc reference
O/P	-Output pin

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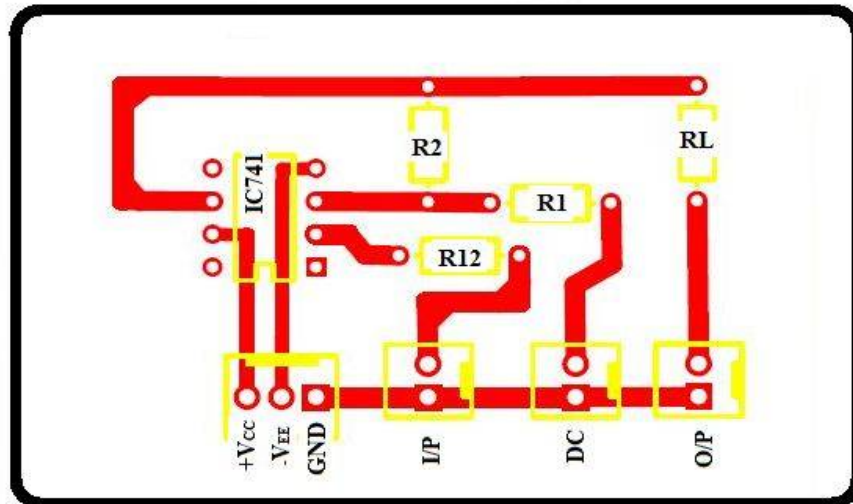


Figure 8: (b) Back end of the kit

Fig 8 b. shows us the traces of copper that we obtained as per our design requirement after performing aforementioned necessary steps. The figure also gives the lucid view of board which indicates how the various components are placed on the board for design optimization and simplicity.

Fig 8 c. shows the pin configuration of IC 741 which is basically an operational amplifier IC. Circuit is designed taking care of the pins of IC.

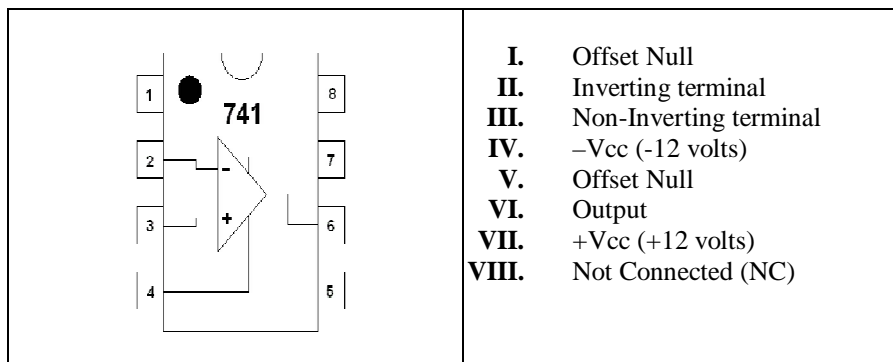


Figure 8: (c) Pin configuration of IC 741



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## VII. PICTURES



Figure 9: (a) Front end of PCB board

Above fig 9 a. shows how the PCB actual looks after transferring the design on the copper clad from the paper and after carrying out the etching process.

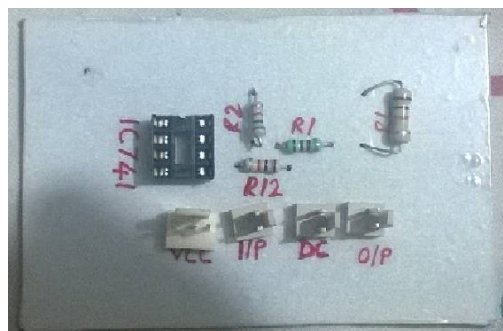


Figure 9: (b) Back end of PCB board

Above fig 9 b. shows the picture of the back end of PCB where the components are placed accurately as indicated in the fig 8 b.

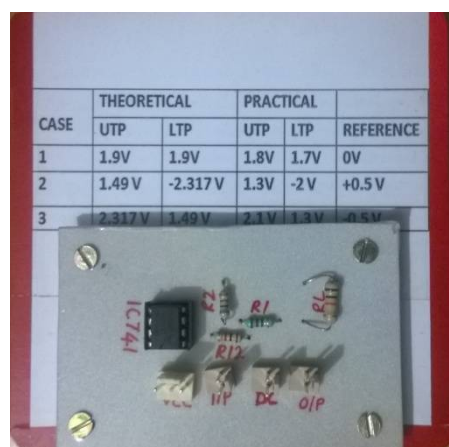


Figure 9: (c) Final Kit

The picture shown in the fig 9 c. indicates how the PCB is placed on the supporting board which is provided with a label indicating the theoretical and practical values of UTP and LTP for different values of reference voltages provided to the circuit.



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## APPLICATION

1. They are used in circuits for noise immunity.
2. Analog to digital conversion.
3. As an oscillator.
4. Level detection of a signal.

## ADVANTAGES

1. All the components are fixed.
2. Less chances of short circuits and wrong connections.
3. Inexpensive for mass production.
4. Does require further inspection of circuits.
5. As this can be done at home, it doesn't require high skills.

## FUTURE SCOPE

This idea can be further implemented to other circuits' as well, which will help the students in laboratory to complete their task in less period of time as they need not have rig up the circuit on breadboard. Secondly as this PCB is designed for fixed values of output it can be further improved for variable values. Once a design is completed it can be used to develop multiple kits.

## VIII. ACKNOWLEDGEMENT

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