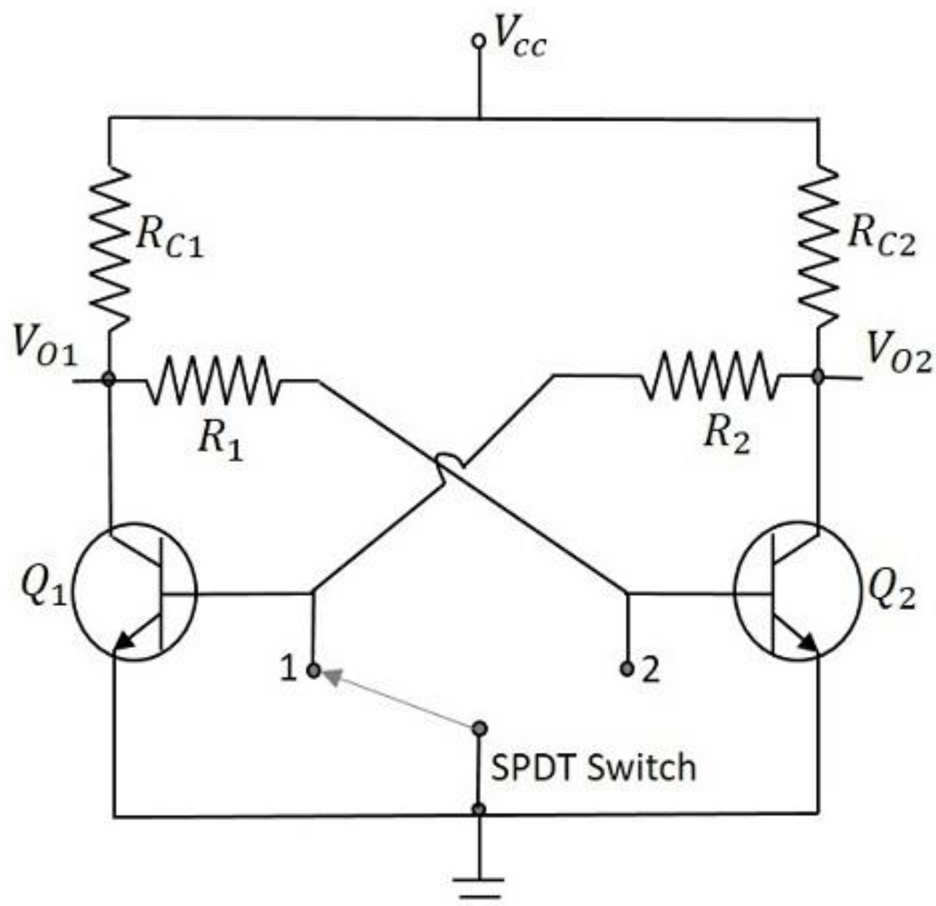
UNIT-1 MPHYCC-12

Schmitt trigger

This circuit is considered as a special type of its kind for its applications.

The main difference in the construction of this circuit is that the coupling from the output C_2 of the second transistor to the base B1 of the first transistor is missing and that feedback is obtained now through the resistor R_e. This circuit is called as the **Regenerative circuit** for this has a **positive feedback** and **no Phase inversion**. The circuit of Schmitt trigger using BJT is as shown below.



Initially we have Q_1 OFF and Q_2 ON. The voltage applied at the base of Q_2 is V_{CC} through R_{C1} and R_1. So the output voltage will be

$$V_0 = V_{CC} - (I_{C2} R_{C2})$$

As Q_2 is ON, there will be a voltage drop across R_E, which will be $(I_{C2} + I_{B2}) R_E$. Now this voltage gets applied at the emitter of Q_1. The input voltage is increased and until Q_1 reaches cut-in voltage to turn ON, the output remains LOW. With Q_1 ON, the output will increase as Q_2 is also ON. As the input voltage continues to rise, the voltage at the points C_1 and B_2 continue to fall and E_2 continues to rise. At certain value of the input voltage, Q_2 turns OFF. The output voltage at this point will be V_{CC} and remains constant though the input voltage is further increased.

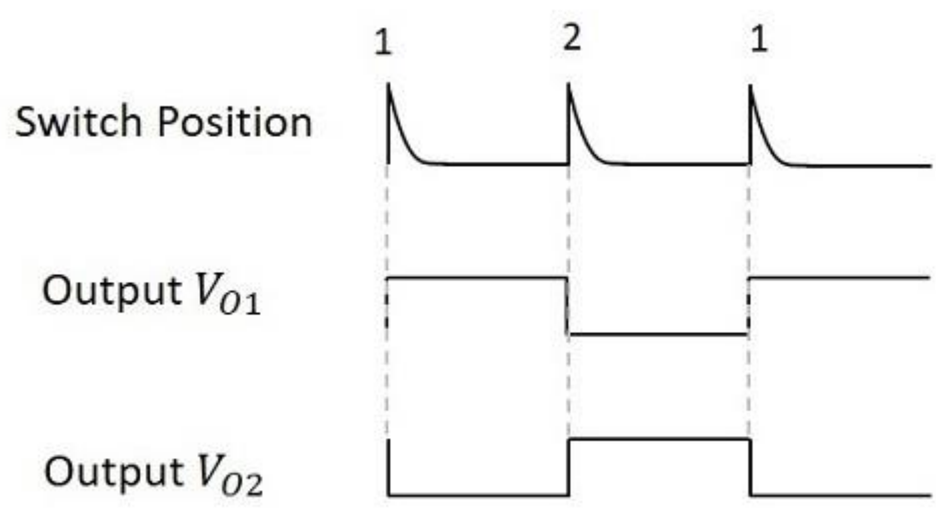
As the input voltage rises, the output remains LOW until the input voltage reaches V_1 where

$$V1=[V_{CC}-(I_{C2}R_{C2})]$$

The value where the input voltage equals V_1, lets the transistor Q_1 to enter into saturation, is called **UTP** (Upper Trigger Point). If the voltage is already greater than V_1, then it remains there until the input voltage reaches V_2, which is a low level transition. Hence the value for which input voltage will be V_2 at which Q_2 gets into ON condition, is termed as **LTP** (Lower Trigger Point).

Output Waveforms

The output waveforms are obtained as shown below.



The Schmitt trigger circuit works as a **Comparator** and hence compares the input voltage with two different voltage levels called as **UTP** (Upper Trigger Point) and **LTP** (Lower Trigger Point). If the input crosses this UTP, it is considered as a

HIGH and if it gets below this LTP, it is taken as a LOW. The output will be a binary signal indicating 1 for HIGH and 0 for LOW. Hence an analog signal is converted into a digital signal. If the input is at intermediate value (between HIGH and LOW) then the previous value will be the output.

This concept depends upon the phenomenon called as **Hysteresis**. The transfer characteristics of electronic circuits exhibit a **loop** called as **Hysteresis**. It explains that the output values depends upon both the present and the past values of the input. This prevents unwanted frequency switching in Schmitt trigger circuits

Advantages

The advantages of Schmitt trigger circuit are

- Perfect logic levels are maintained.
- It helps avoiding Meta-stability.
- Preferred over normal comparators for its pulse conditioning.

Disadvantages

The main disadvantages of a Schmitt trigger are

- If the input is slow, the output will be slower.
- If the input is noisy, the output will be noisier.

Applications of Schmitt trigger

Schmitt trigger circuits are used as Amplitude Comparator and Squaring Circuit. They are also used in Pulse conditioning and sharpening circuits.

These are the Multivibrator circuits using transistors. The same Multivibrators are designed using operational amplifiers and also IC 555 timer circuits.

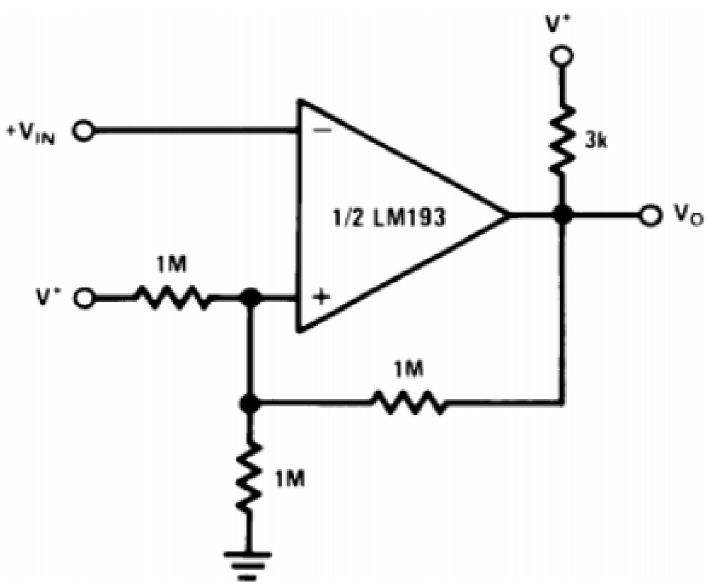
Why Schmitt Triggers?

Comparators by nature are very fast, since they lack the compensating capacitor found in their op-amp cousins. Comparators are not limited by output slew rate and transition times are in the order of nanoseconds. Comparators also have especially sensitive inputs because of their very high gain – even tiny changes in the input can cause instant change of state on the output. This problem gets worse when the differential input signals reach the dead zone, that is, the minimum input differential voltage required to maintain a stable output. Within this narrow range, the comparator has no idea what to do with its output – which leads to something called motorboating, which is the output oscillating. This problem also occurs with signals that have a slow transition time – the input signal spends enough time in the dead zone (with reference to the reference voltage, of course) to create multiple output transitions, as shown in the figure below.

A **Schmitt trigger** makes use of **positive feedback** – it takes a sample of the output and feeds it back into the input so as to 'reinforce', so to speak, the output – which is the exact opposite to negative feedback, which tries to nullify any changes to the output.

This reinforcing property is useful – it makes the comparator decide the state of the output it wants, and makes it stay there, even within what would normally be the dead zone.

Consider this simple circuit:



INVERTING COMPARATOR WITH HYSTERESIS

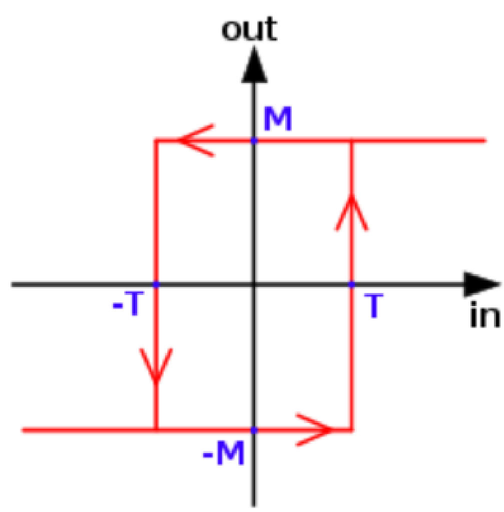
Assume the input voltage is lower than the reference voltage at the non-inverting pin and the output is therefore high.

V* is the reference input voltage which creates a fixed bias at the non-inverting input. Since the output is high through the pullup resistor, this creates a current path through the feedback resistor, slightly increasing the reference voltage.

When the input goes above the reference voltage, the output goes low. Normally this shouldn't affect the reference voltage in any way, but since there's a feedback resistor, the reference voltage drops slightly below the nominal value because the feedback and the lower reference resistor are now in parallel with respect to ground (since a low output shorts that terminal of the resistor to ground). Since the reference voltage is lowered, there is no chance of a small change in input causing multiple transitions – in other words, there is no longer a dead zone.

To cause the output to go high, the input must now cross the new lower threshold. Once crossed, the output goes high and the circuit is 'reset' to the initial configuration. The input has to cross the threshold just once resulting in a single clean transition. The circuit now has two effective thresholds or states – it is bistable.

This can be summarised in the form of a graph:



HYSTERESIS CURVE

This can be understood in the usual sense – the x axis is the input and y axis is the output. Tracing a line from x to y, we find that once the lower threshold has been crossed, the hysteresis goes high and vice versa.

The operation of the non-inverting comparator is similar – the output again changes the configuration of a resistor network to change the threshold to prevent unwanted oscillations or noise.