Schmitt Trigger

Schmitt trigger converts an irregular-shaped waveform to a square wave or pulse. A Schmitt trigger circuit is a fast-operating voltage-level detector. When the input voltage arrives at the upper or lower trigger levels, the output changes rapidly. The circuit operates with almost any type of input waveform, and it gives a pulse-type output.

The circuit of an op-amp Schmitt trigger circuit is shown in figure. The input voltage v_{in} is applied to the inverting input terminal and the feedback voltage goes to the non-inverting terminal. This means the circuit uses positive voltage feedback instead of negative feedback, that is, in this circuit feedback voltage aids the input voltage rather than opposing it. For instance, assume the inverting input voltage to be slightly positive. This will produce a negative output voltage. The voltage divider feeds back a negative voltage to the non-inverting input, which results in a larger negative voltage. This feeds back more negative voltage until the circuit is driven into negative saturation. If the input voltage were, slightly negative instead of positive, the circuit would be driven into the positive saturation. This is the reason the circuit is also referred to as regenerative comparator.

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

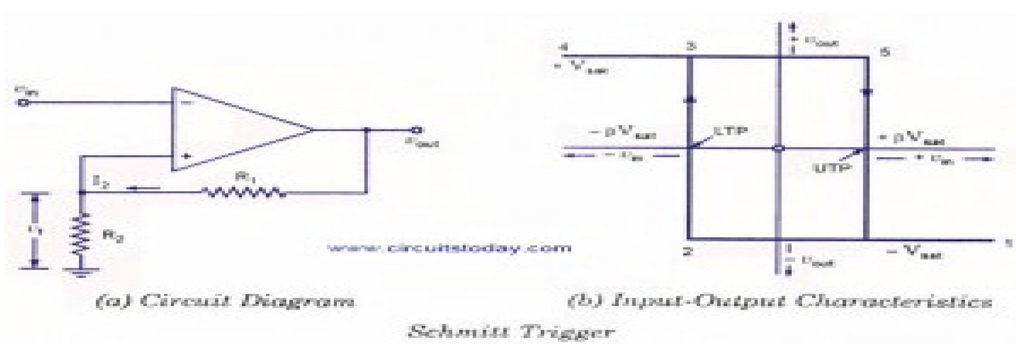

Figure 4.7

The feedback fraction, $\beta = R_2/R_1 + R_2$

When the output is positively saturated, the reference voltage applied to the non-inverting input is

$$\mathbf{V_{ref}{}^{=+}\,\beta V_{sat}}$$

When the output is negatively saturated, the reference voltage is

$$\mathbf{V_{ref}{}^{=-}\,\beta V_{sat}}$$

The output voltage will remain in a given state until the input voltage exceeds the reference voltage for that state. For instance, if the output is positively saturated, the reference voltage is + βV_{sat}. The input voltage v_{in} must be increased slightly above + β V_{sat} to switch the output voltage from positive to negative, as shown in figure. Once the output is in the negative state, it will remain there indefinitely until the input voltage becomes more negative than – βV_{sat}. Then the output switches from negative to positive. This can be explained from the input-output characteristics of the Schmitt trigger shown in figure, as below.

Characteristics of the Schmitt trigger

Assume that input voltage v_{in} is greater than the + β V_{sat}, and output voltage v_{OUT} is at its negative extreme (point 1). The voltage across R_2 in the figure is a negative quantity.

As a result, v_{in} must be reduced to this negative voltage level (point 2 on the characteristics) before the output switches positively (point 3). If the input voltage is made more negative than the – β V_{sat}, the output remains at + +v_{OUT} (points 3 to 4). For the output to go negative once again, v_{in} must be increased to the + β V_{sat} level (point 5 on the characteristics).

In figure, the trip points are defined as the two input voltages where the output changes states. The upper trip point (abbreviated UTP) has a value

UTP = β V_{sat} and the lower trip point has a value

LTP = – β V_{sat}

The difference between the trip points is the hysteresis H and is given as

H = + β V_{sat} – (-β V_{sat}) = 2 β V_{sat}

The hysteresis is caused due to positive feedback. If there were no positive feedback, β would equal zero and the hysteresis would disappear, because the trip points would both equal zero.

Hysteresis is desirable in a Schmitt trigger because it prevents noise form causing false triggering.

To design a Schmitt trigger, potential divider current I_2 is once again selected to be very much larger than the op-amp input bias current. Then the resistor R_2 is calculated from equation

R_2 = UTP/I_2

and R_1 is determined from

R_1 = (V_{OUT} – UTP) / I_2