Part 1: Schmitt Trigger

Theory

Schmitt trigger is essentially a multivibrator having two stable states. The output remains in one of the stable states indefinitely. The transition from one stable state to the other takes place when the input signal changes appropriately (triggers appropriately). Bistable operation needs an amplifier with a regenerative (positive) feedback with loop gain greater than unity. The circuit is often used to convert square waves with slowly varying edges to sharp edges required in digital circuits. It is also used for debouncing the switches.

The circuit shown in Fig. 1 is that of an inverting Schmitt Trigger. The circuit has two stable state outputs. The output will either be at $+V_{sat}$ or $–V_{sat}$. The circuit uses a potential divider formed by R1 and R2 to provide a positive DC feedback. The circuit is essentially a comparator with positive DC feedback. The voltage at V_A is compared with the input signal. The voltage V_A can take either of the two values $V_{TH} = +\beta V_{sat}$ or $V_{TL}= -\beta V_{sat}$ where, $\beta = R1/ (R1+R2)$.

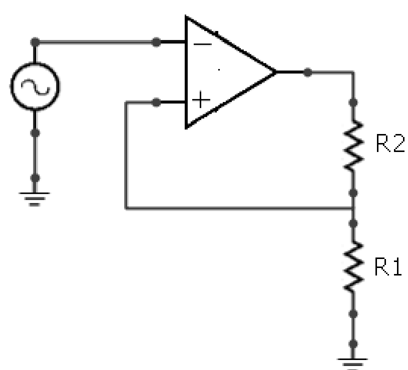

Figure 1 Schmitt Trigget

Refer the transfer characteristic in Fig 2 for understanding how the output changes with the input signal. When the input signal $V_s>V_{TH}$ the output switches to $–V_{sat}$ and remains at this level till $Vs<V_{TL}$ when the output switches to $+V_{sat}$. The values at which the output makes transition from one level to the other are called “Threshold” points or trip points. The input voltage at which the output makes transition from $+V_{SAT}$ to $-V_{SAT}$ is V_{TH} and the input voltage at which the output makes transition from $-V_{SAT}$ to $+V_{SAT}$ is defined as T_{TL}

$$V_{TH} = \frac{R1}{R1+R2} V_{sat}$$

$$V_{TL} = -\frac{R1}{R1+R2} V_{sat}$$

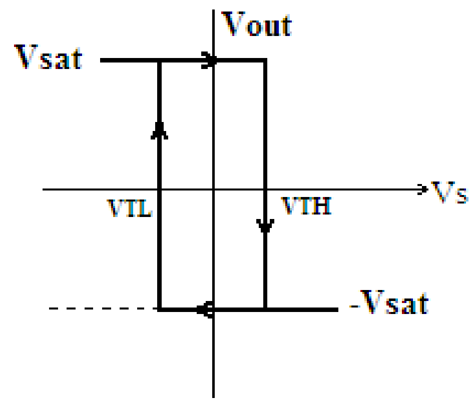

Figure 2 Hysteresis

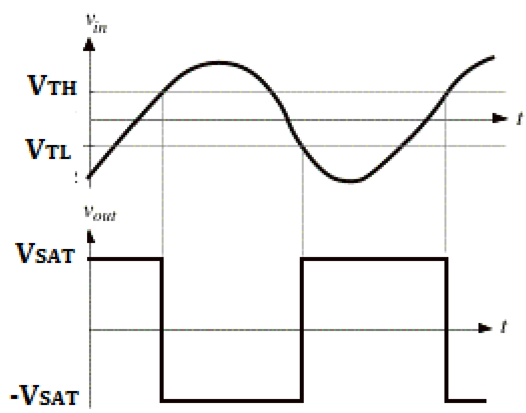

Figure 3 Input and output waveforms

Part 2: Astable multivibrator

An astable multivibrator switches between two states with a frequency determined by an RC time constant. This feature may be used to make a square wave generator.

When the circuit is turned ON, depending upon the initial conditions, the op amp's output saturates to either positive or negative rail. Assuming that the op amp saturates at the positive rail, the capacitor starts charging through the resistor R, and the voltage across the capacitor starts to rise exponentially. As soon as the voltage at the op amp's inverting terminal tries to cross that at the noninverting terminal (the op amp's output voltage fed back by the potential divider formed by R1 and R2), the output switches over to the opposite rail as shown in Fig and the capacitor starts to discharge through R1 exponentially. Once the inverting terminal reaches the voltage of the non-inverting terminal, the output again drives to the opposing rail voltage and the cycle begins again. Thus, the astable multivibrator creates a square wave with no inputs.

The voltage at noninverting terminal is thus,

$$V_f = \pm \frac{R2}{R1+R2} V_{sat} = \pm \beta V_{sat}$$

The voltage across the capacitor or voltage at inverting terminal is given by,

$$V_c = \pm V_{sat}\left(1 - e^{-t/RC}\right)$$

The switching from one state to the other takes place when $V_c = V_f$. Solving these two for charging and discharging voltages of the capacitor we get the time period of the output waveform (T1+T2) as,

$$T = 2RCln\left(1 + \frac{2R_2}{R_1}\right)$$

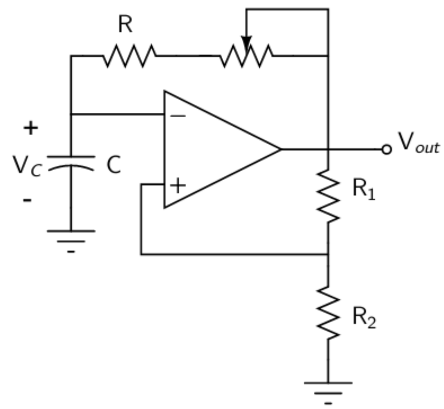

Figure 4 Astable Multivibrator

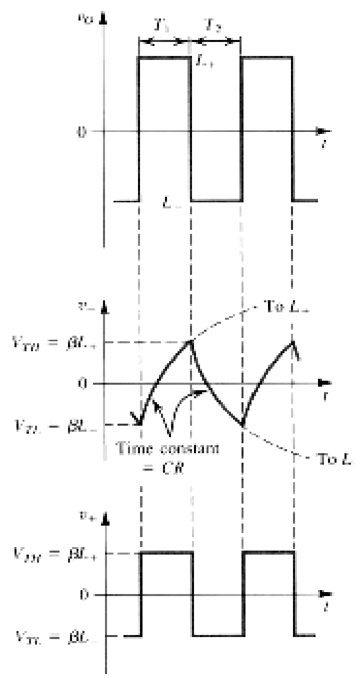

Figure 5 Input Output waveforms