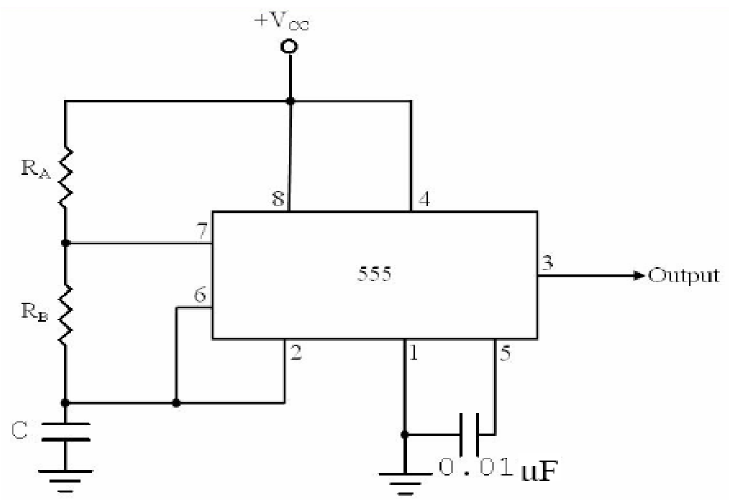
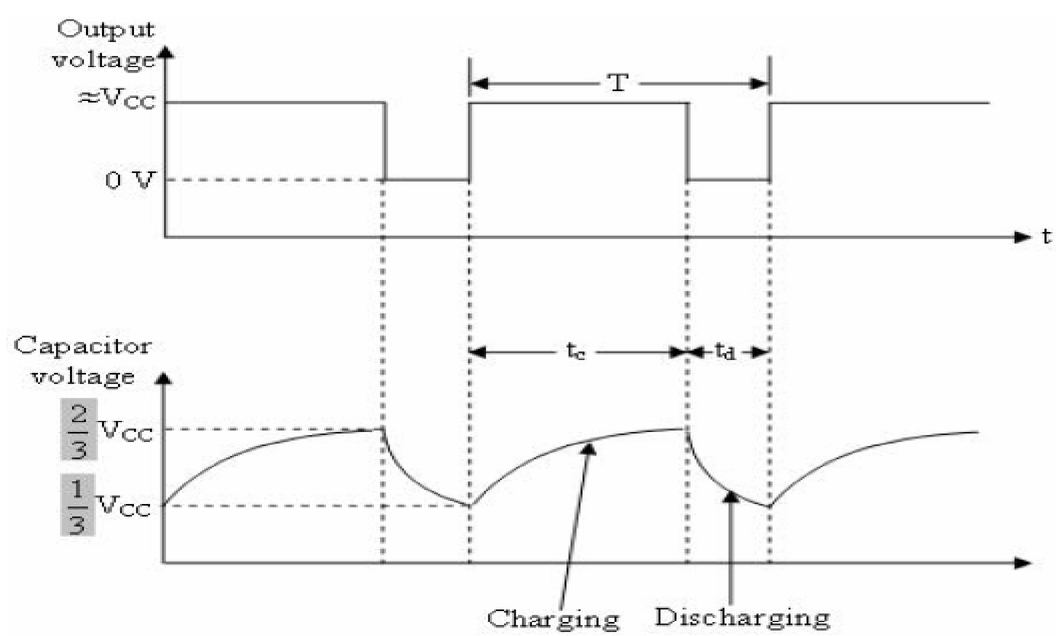
THE 555 TIMER AS AN ASTABLE MULTIVIBRATOR

An Astable multivibrator, often called a free running multivibrator, is a rectangular wave generating circuit. Unlike the monostable multivibrator, this circuit does not require an external trigger to change the state of the output, hence the name free running. However, the time during which the output is either high or low is determined by 2 resistors and capacitors, which are externally connected to the 55 timer.

Fig: Astable Multivibrator



Model Graph



The above figures show the 555 timer connected as an astable multivibrator and its model graph

Initially, when the output is high :

Capacitor C starts charging toward Vcc through R_A & R_B. However, as soon as voltage across the capacitor equals 2/3 Vcc. Upper comparator triggers the FF & output switches low.

When the output becomes Low:

Capacitor C starts discharging through R_B and transistor Q1, when the voltage across C equals 1/3 Vcc, lower comparator output triggers the FF & the output goes High. Then cycle repeats. The capacitor is periodically charged & discharged between 2/3 Vcc & 1/3 Vcc respectively. The time during which the capacitor charges from 1/3 Vcc to 2/3 Vcc equal to the time the output is high & is given by

$t_c = (R_A+R_B)C \ln 2$……………(1) Where [ln 2 = 0.69]

$= 0.69\,(R_A+R_B)C$

Where R_A & R_B are in ohms. And C is in farads.

Similarly, the time during which the capacitors discharges from 2/3 Vcc to 1/3 Vcc is equal to the time, the output is low and is given by,

$t_c = R_B\,C \ln 2$

$t_d = 0.69\,R_B\,C$ …………………..(2)

where R_B is in ohms and C is in farads.

Thus the total period of the output waveform is

$T = t_c + t_d = 0.69\,(R_A+2R_B)C$ …………….(3)

This, in turn, gives the frequency of oscillation as,$f_0 = 1/T = 1.45/(R_A+2R_B)C$ ………(4)

Equation 4 indicates that the frequency f_0 is independent of the supply voltage Vcc. Often the term duty cycle is used in conjunction with the astable multivibrator. The duty cycle is the ratio of the time t_c during which the output is high to the total time period T. It is generally expressed as a percentage.

$$\% \text{ duty cycle} = (t_c / T) * 100$$

$$\% \text{ DC} = [(R_A+R_B)/ /(R_A+2R_B)] * 100$$

Astable Multivibrator Applications:

(a) Square wave oscillator:

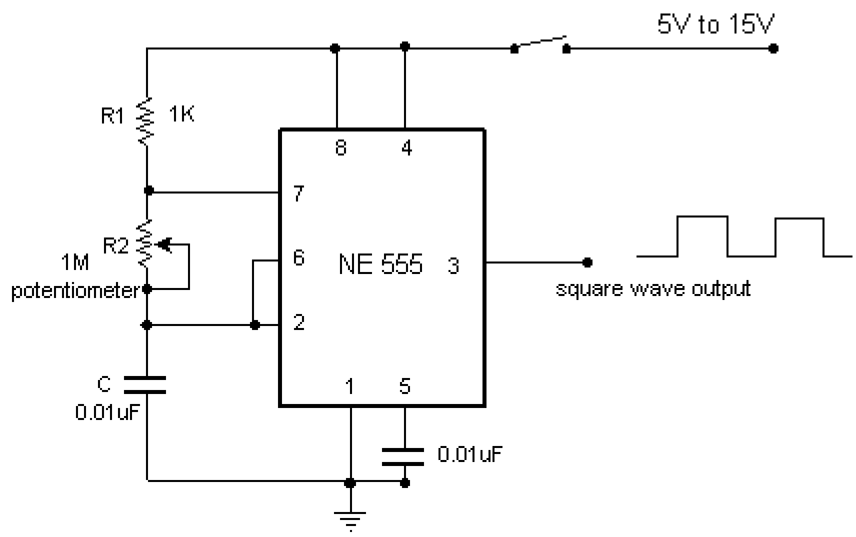


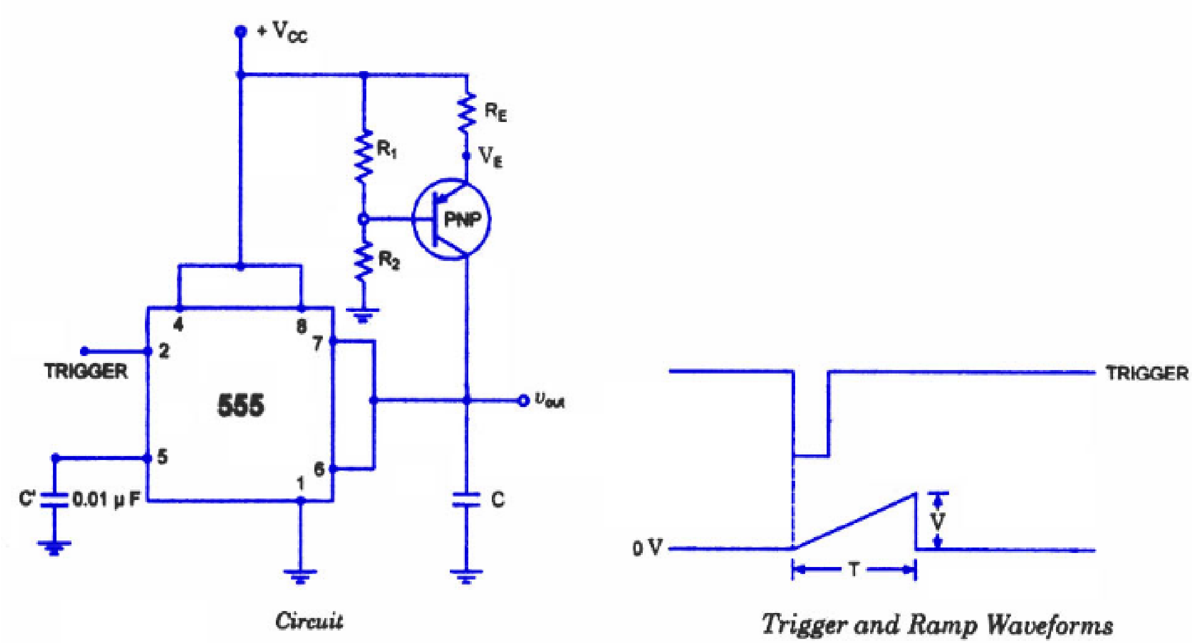
Fig: Square Wave Oscillator

With out reducing R_A = 0 ohm, the astable multivibrator can be used to produce square wave output. Simply by connecting diode D across Resistor R_B. The capacitor C charges through R_A & diode D to approximately

2/3 Vcc & discharges through R_B & Q1 until the capacitor voltage equals approximately 1/3 Vcc, then the cycle repeats.

To obtain a square wave output, R_A must be a combination of a fixed resistor & potentiometer so that the potentiometer can be adjusted for the exact square wave.

(b) Free – running Ramp generator:



Ramp Generator Using The Timer 555

- The astable multivibrator can be used as a free – running ramp generator when resistor R_A & R_B are replaced by a current mirror.
- The current mirror starts charging capacitor C toward Vcc at a constant rate.
- When voltage across **C equals to 2/3 Vcc**, upper comparator turns transistor Q1 ON & C rapidly discharges through transistor Q1.
- When voltage across **C equals to 1/3 Vcc**, lower comparator switches transistor OFF & then capacitor C starts charging up again..
- Thus the charge – discharge cycle keeps repeating.
- The discharging time of the capacitor is relatively negligible compared to its charging time.
- The time period of the ramp waveform is equal to the charging time & is approximately is given by,

$$T = VccC/3I_C \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (1)$$

$$I_C = (Vcc - V_{BE})/R = \text{constant current}$$

Therefore the free – running frequency of ramp generator is

$$f_0 = 3I_C/ Vcc\ C \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$