ASTABLE MULTIVIBRATOR

IC 555 Timer as Multivibrator

The 555 can operate in either mono/bi-stable or astable mode, depending on the connections to and the arrangement of the external components. Thus, it can either produce a single pulse when triggered, or it can produce a continuous pulse train as longas it remains powered.

Astable multivibrator

These circuits are not stable in any state and switch outputs after predetermined time periods. The result of this is that the output is a continuous square/rectangular wave with the properties depending on values of external resistors and capacitors. Thus, while designing these circuits following parameters need to be determined:

1. Frequency (or the time period) of the wave.
2. The duty cycle of the wave.

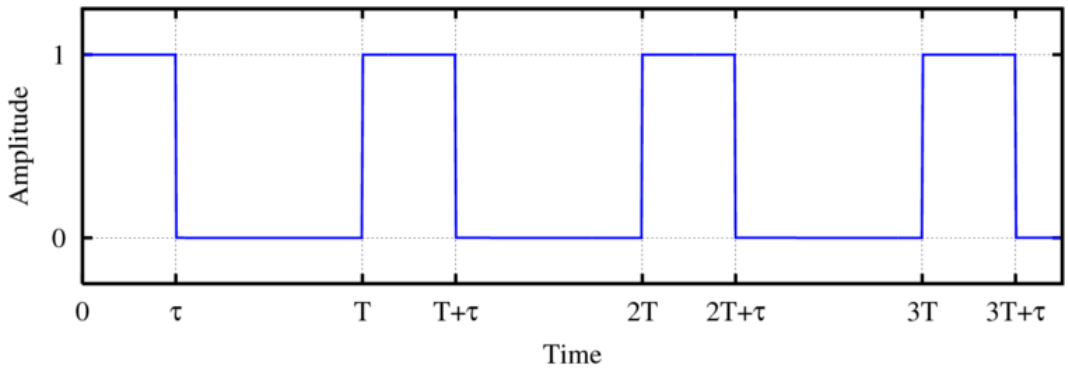


Figure 1: A rectangular waveform

Referring to the above figure of a rectangular waveform, the time period of the pulse is defined as T and duration of the pulse (ON time) is τ. Duty cycle can be defined as the On time/Period that is, τ/T in the above figure. Obviously, a duty cycle of 50% will yield a square wave.

The key external component of the **astable timer** is the *capacitor*. An astable multivibrator can be designed as shown in the circuit diagram (with typical component values) using IC 555, for a duty cycle of more than 50%. The corresponding voltage across the capacitor and voltage at output is also shown. The astable function is achieved by charging/discharging a capacitor through resistors connected, respectively, either to V_{CC} or GND. Switching between the charging and discharging modes is handled by

resistor divider R1-R3, two Comparators, and an RS Flip-Flop in IC 555. The upper or lower comparator simply generates a positive pulse if V_C goes above 2/3 V_{CC} or below1/3 V_{CC}. And these positive pulses either SET or RESET the Q output.

The time for charging C from 1/3 to 2/3 Vcc, i.e, **ON Time = 0.693 (R_A + R_B). C**
The time for discharging C from 2/3 to 1/3 Vcc, i.e. **OFF Time = 0.693 R_B. C**
To get the total oscillation period, just add the two:

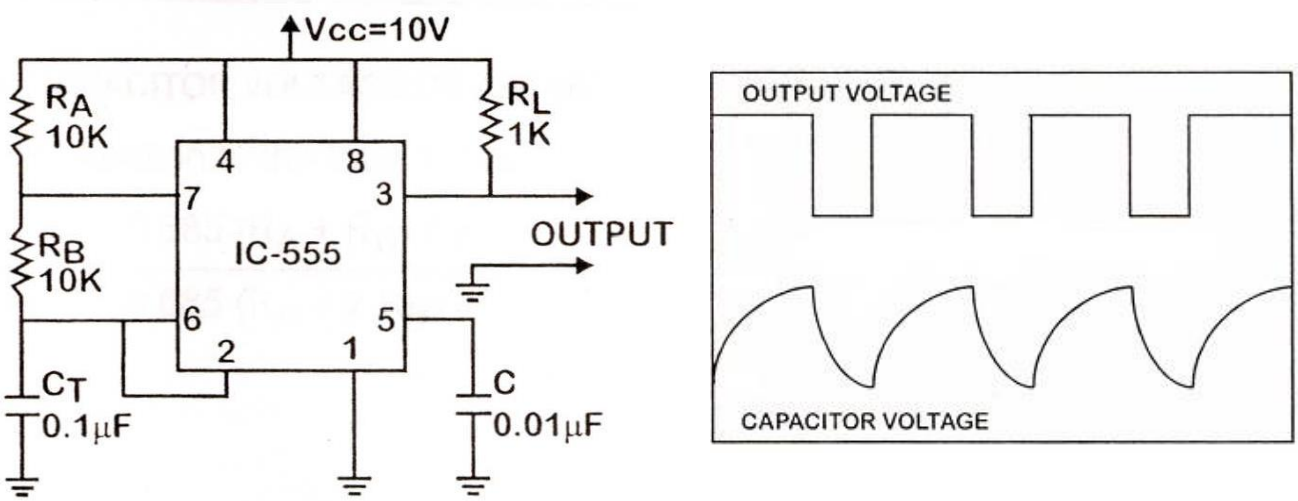
$$T_{osc} = 0.693\cdot(R_A+R_B)\cdot C + 0.693\cdot(R_B)\cdot C = 0.693 \cdot (R_A + 2\cdot R_B) \cdot C$$

Thus,

$$f_{osc} = 1/ T_{osc} = 1.44/(R_A + 2\cdot R_B).C$$

$$\text{Duty cycle} = R_A+R_B/ R_A + 2\cdot R_B$$

Circuit Diagram:



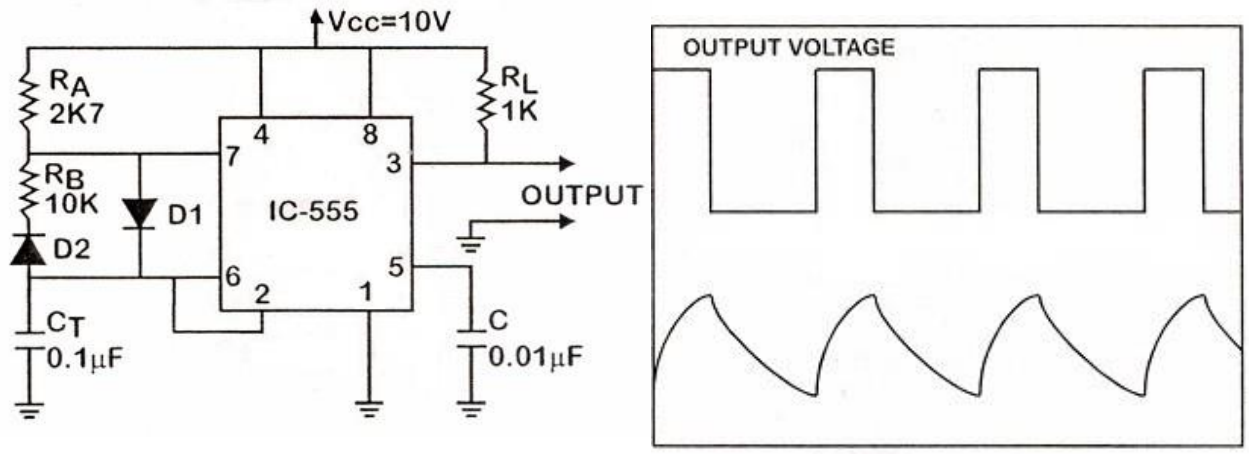
Astable multivibrator with duty cycle less than 50%:

Generally astable mode of IC 555 is used to obtain the duty cycle between 50 to 100%. But for a duty cycle less than 50%, the circuit can be modified as per the circuit diagram. Here a diode D1 is connected between the discharge and threshold terminals (as also across R_B). Thus the capacitor now charges only through R_A (since R_B is shorted by diode conduction during charging) and discharges through R_B. Another optional diode D2 is also connected in series with R_B in reverse direction for better shorting of R_B. Therefore, the frequency of oscillation and duty cycle are

$$f_{osc} = 1/ T_{osc} = 1.44/(R_A + R_B).C$$

$$\text{Duty Cycle} = R_A/ (R_A + R_B)$$

Circuit Diagram:



Astable multivibrator with duty cycle variable from 0 to 100%:

In some applications, it is needed to vary the duty cycle from about 0 to 100%. In thatcase the circuit is designed as shown in the circuit diagram. Here a potentiometer, R_X, is used so that $R_A = R_1+R_2$, $R_B = R_X-R_2+R_3$. A diode is now connected across a variable R_B. Thus a variable duty cycle is achieved. Therefore, the frequency of oscillation and duty cycle can be derived as follows.

$$\mathbf{f_{osc} = 1/ T_{osc} = 1.44/(R_A + R_B).C = 1.44/(R_1 + R_X + R_3).C}$$

$$\mathbf{Min.\ Duty\ Cycle = R_1/(R_1 + R_X + R_3)\ Max.\ Duty\ Cycle = (R_1 + R_X)/(R_1 + R_X + R_3)}$$

Circuit Diagram: