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.

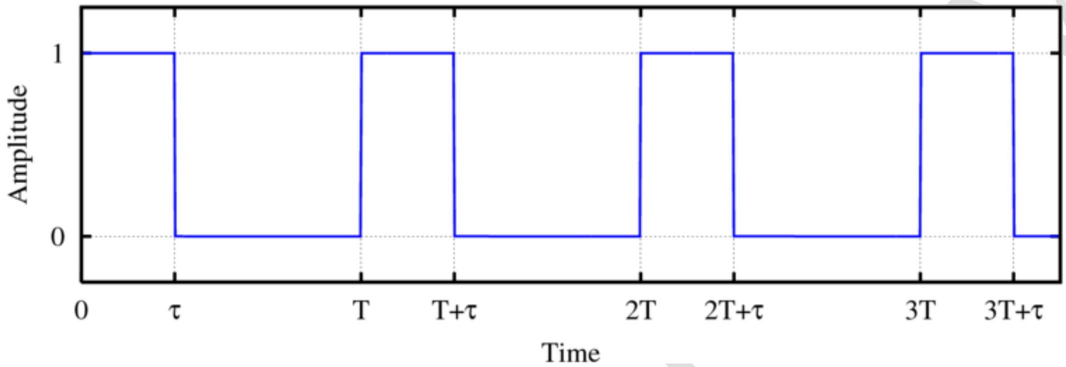


Figure 1: A rectangular waveform

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 below 1/3 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:

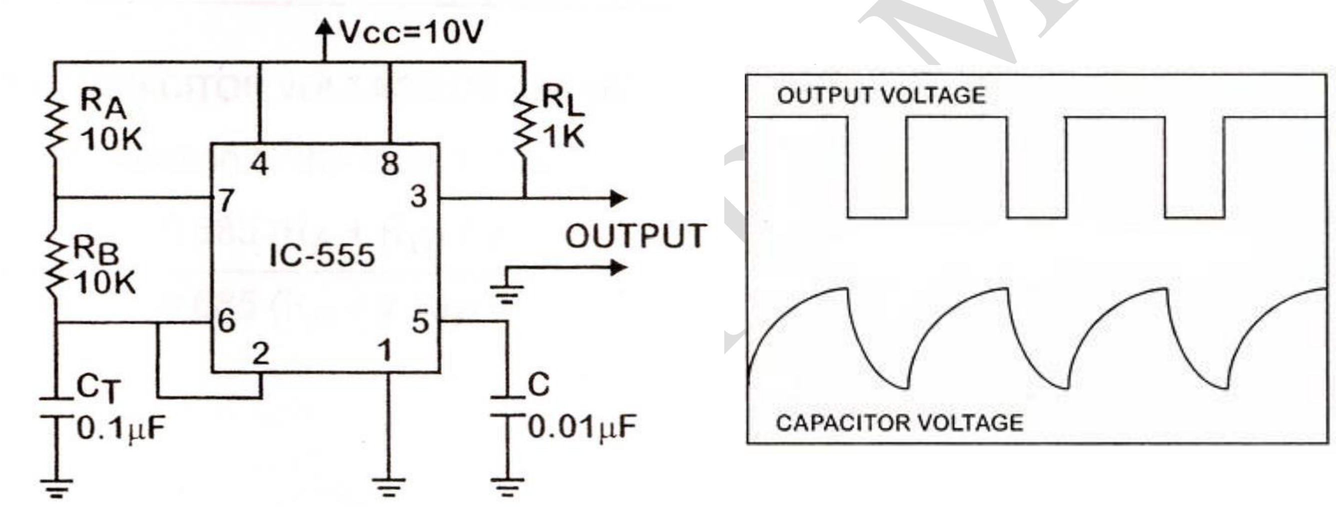
$$T_{osc} = 0.693\cdot(R_A+R_B)\cdot C + 0.693\cdot(R_B)\cdot C = 0.693 \cdot (R_A + 2\cdot R_B) \cdot C$$

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:



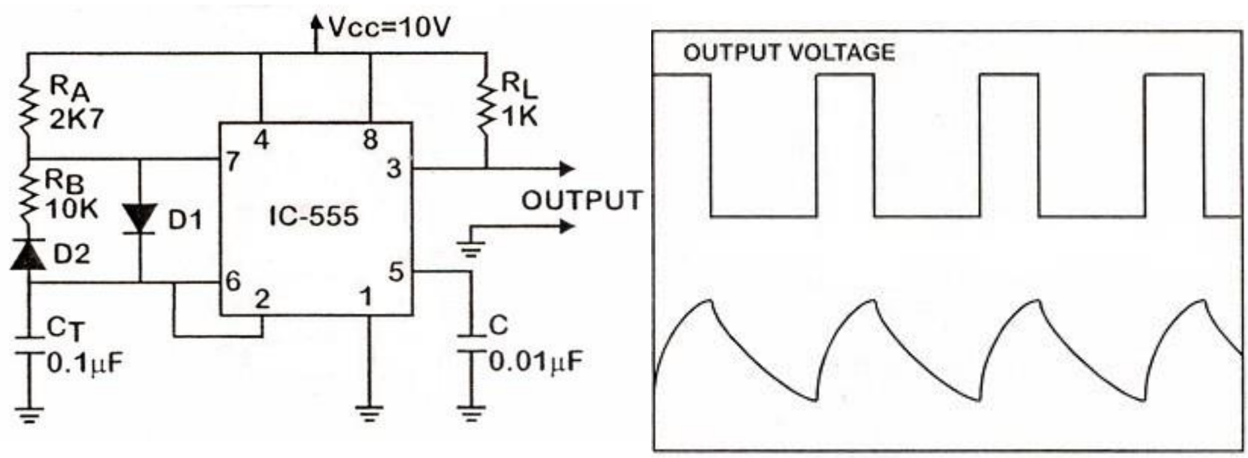
Astable multivibrator with duty cycle less than 50%:

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%:

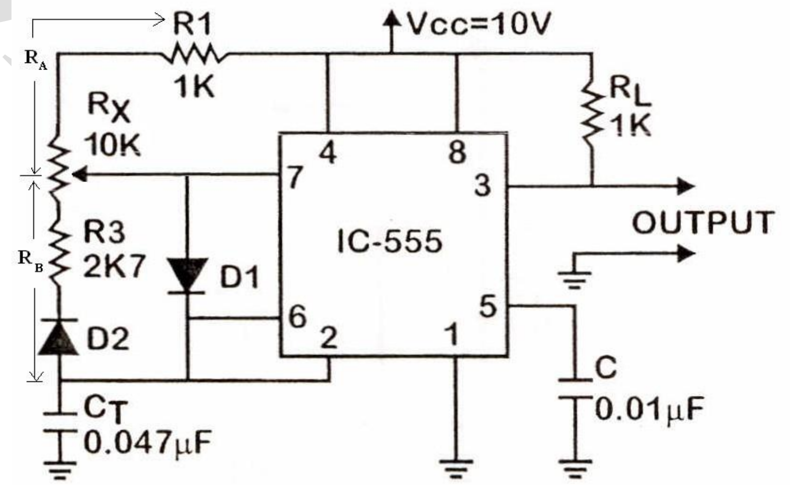
In some applications, it is needed to vary the duty cycle from about 0 to 100%. In that case the circuit is designed as shown in the circuit diagram. Here a potentiometer, R_X, is used so that $R_A = R_1+R_2$, $R_B = R_X-R_2+R_3$. A diode is now connected across a variable R_B. Thus a variable duty cycle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

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

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

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

Circuit Diagram



Applications:

Astable Multivibrators are used in many applications such as amateur radio equipment, Morse code generators, timer circuits, analog circuits, and TV systems.