**Astable multivibrator**

These circuits are not stable in any state and switch outputs after predefined 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.

![A rectangular waveform](image)

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 $\tau$. Duty cycle can be defined as the On time/Period that is, $\tau/T$ 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 \( V_{CC} \), i.e., **ON Time** = 0.693 \( (R_A + R_B) \cdot C \)
The time for discharging \( C \) from 2/3 to 1/3 \( V_{CC} \), i.e., **OFF Time** = 0.693 \( R_B \cdot C \)
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,

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

**Duty cycle** = \( \frac{R_A + R_B}{R_A + 2\cdot R_B} \)

**Circuit Diagram:**

![Astable multivibrator with duty cycle less than 50%](image)

**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 \( D_1 \) 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 \( D_2 \) 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

\[
f_{osc} = 1/ T_{osc} = 1.44/(R_A + R_B) \cdot C
\]

**Duty Cycle** = \( \frac{R_A}{R_A + R_B} \)
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.

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

**Min. Duty Cycle** = $\frac{R_1}{(R_1 + R_X + R_3)}$

**Max. Duty Cycle** = $\frac{(R_1 + R_X)}{(R_1 + R_X + R_3)}$
Applications:
Astable Multivibrators are used in many applications such as amateur radio equipment, Morse code generators, timer circuits, analog circuits, and TV systems.