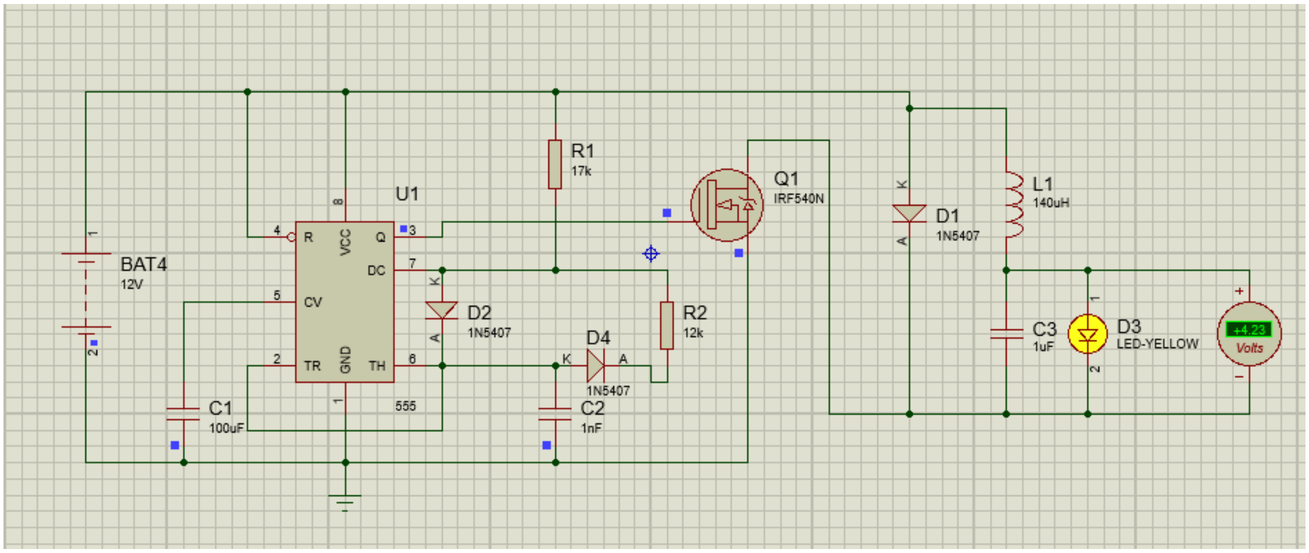
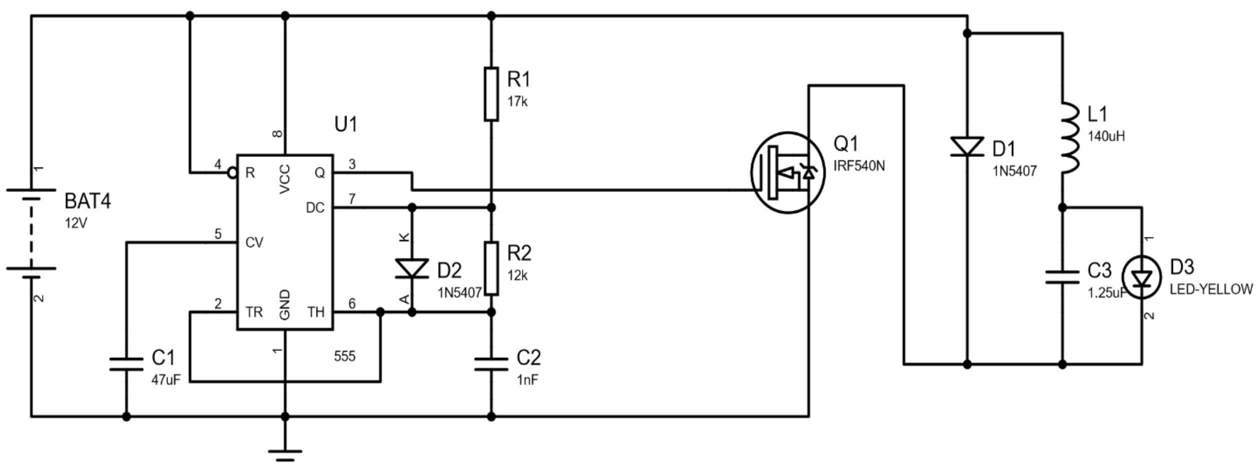
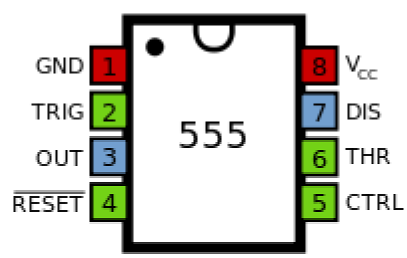


R1
17k
U1
Q1
IRF540N
D1
1N5407
L1
140uH
BAT4
12V
R
VCC
Q
DC
CV
TR
GND
TH
555
D2
1N5407
D4
1N5407
R2
12k
C1
100uF
C2
1nF
C3
1uF
D3
LED-YELLOW
Volts



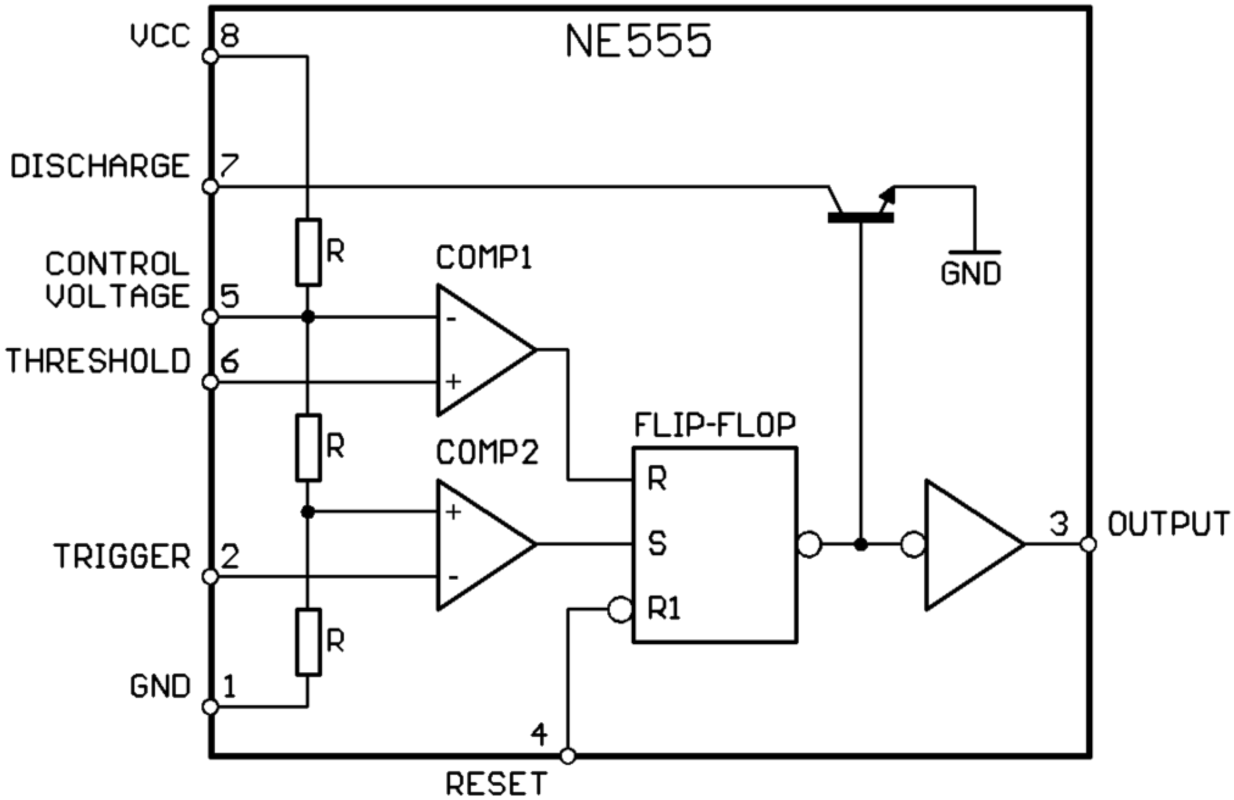
R1
17k
U1
Q1
IRF540N
D1
1N5407
L1
140uH
BAT4
12V
R
VCC
Q
DC
CV
TR
GND
TH
555
D2
1N5407
R2
12k
C1
47uF
C2
1nF
C3
1.25uF
D3
LED-YELLOW

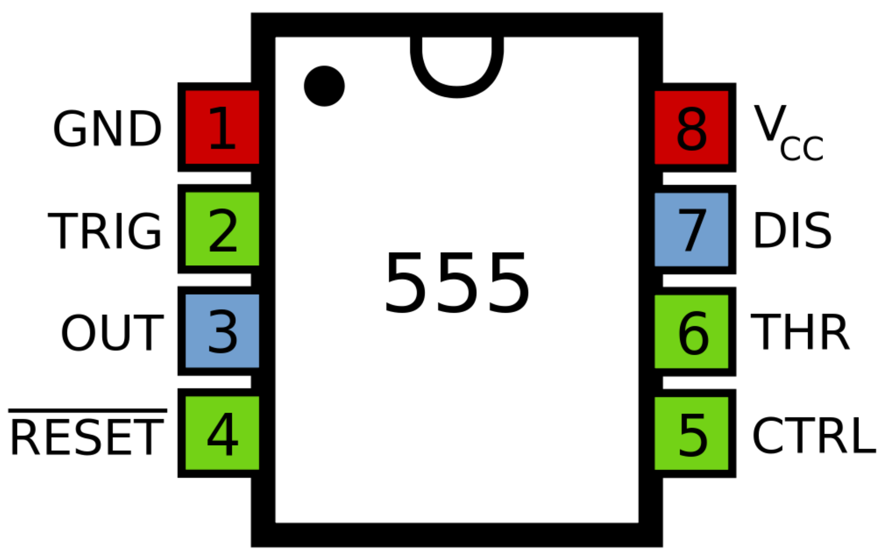
NE555N
7828



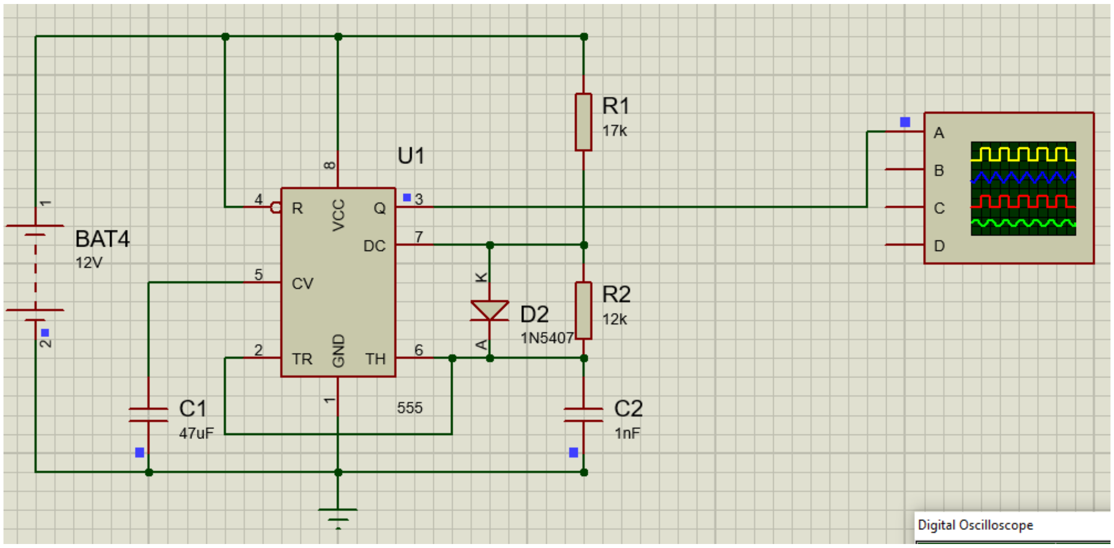
GND 1
TRIG 2
OUT 3
RESET 4
555
8 V_{CC}
7 DIS
6 THR
5 CTRL

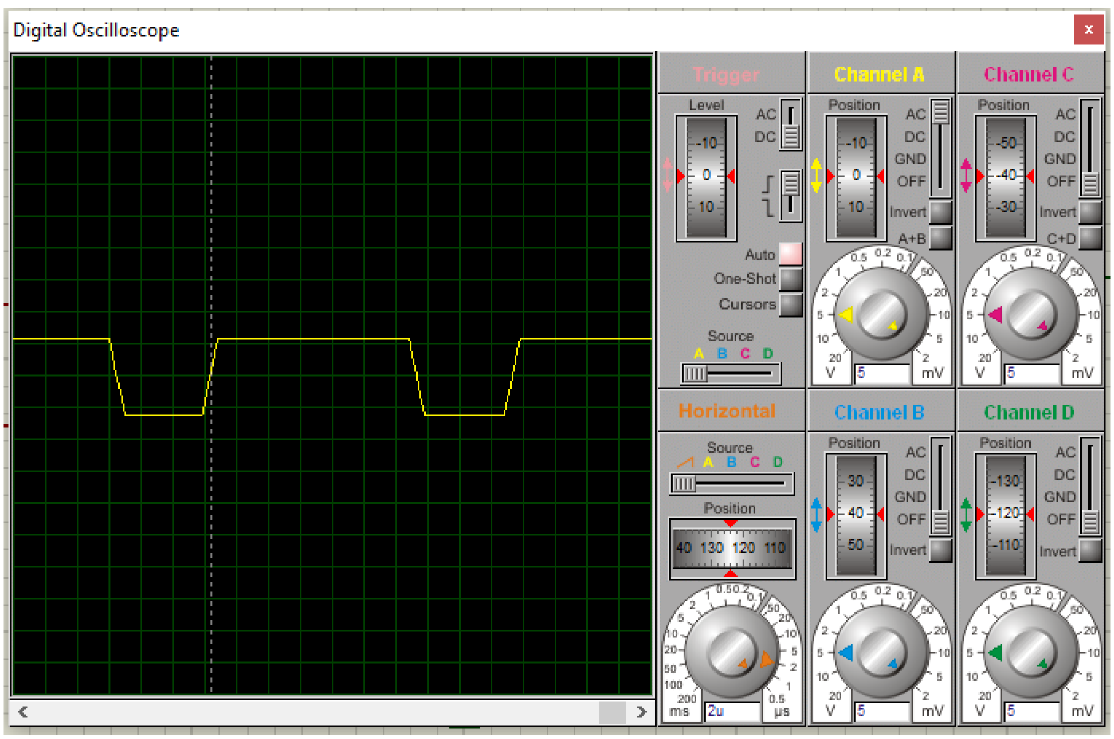
timer 555


NE555
VCC
8
DISCHARGE
7
CONTROL
VOLTAGE
5
THRESHOLD
6
TRIGGER
2
GND
1
R
R
R
COMP1
COMP2
FLIP-FLOP
R
S
R1
GND
3
OUTPUT
4
RESET


555
GND
1
TRIG
2
OUT
3
RESET
4
8
V CC
7
DIS
6
THR
5
CTRL

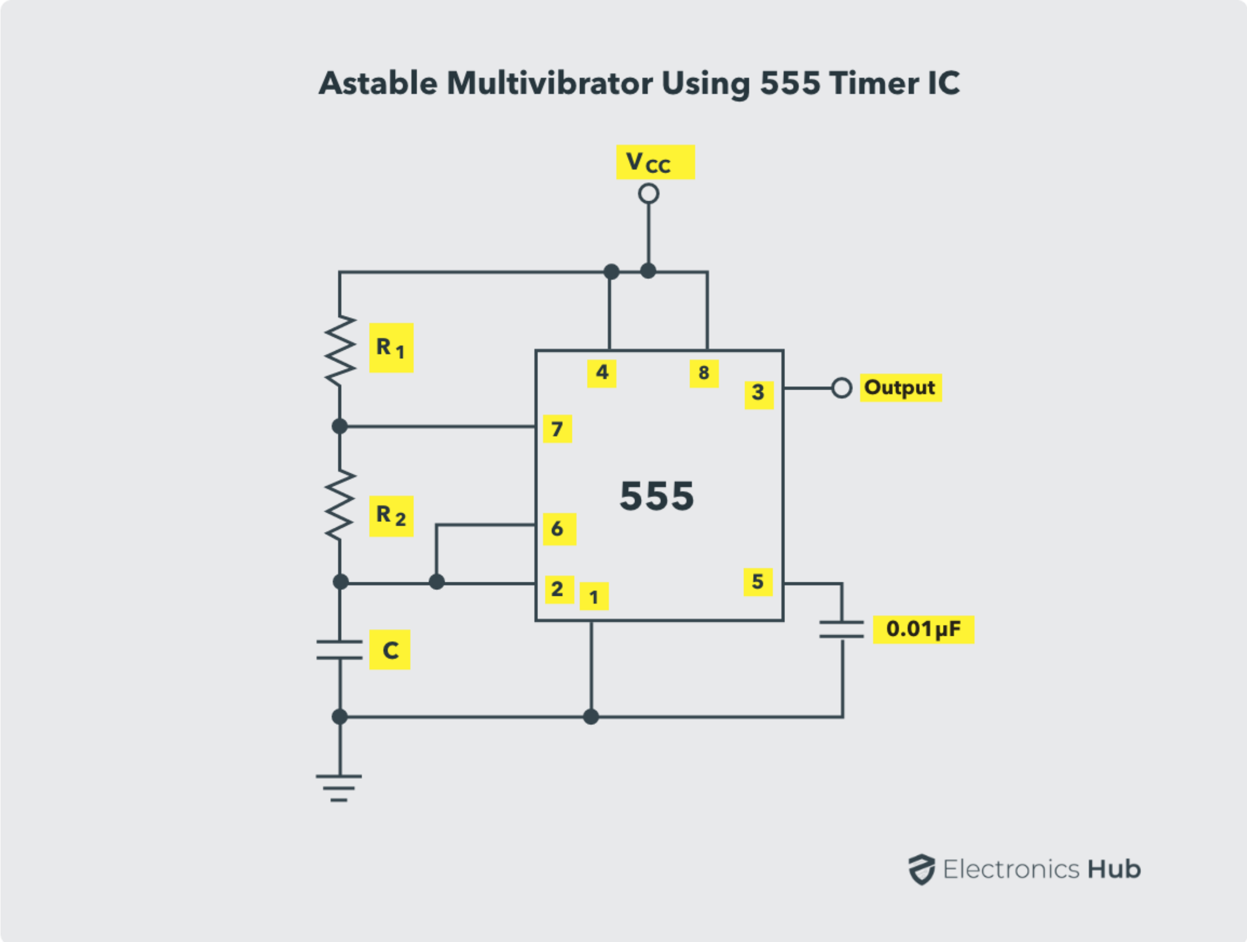
Astable Multivibrator Mode of 555 Timer IC





Circuit

Astable multivibrator is also called as Free Running Multivibrator. It has no stable states and continuously switches between the two states without application of any external trigger. The IC 555 can be made to work as an astable multivibrator with the addition of three external components: two resistors (R_1 and R_2) and a capacitor (C). The schematic of the IC 555 as an astable multivibrator along with the three external components is shown below.

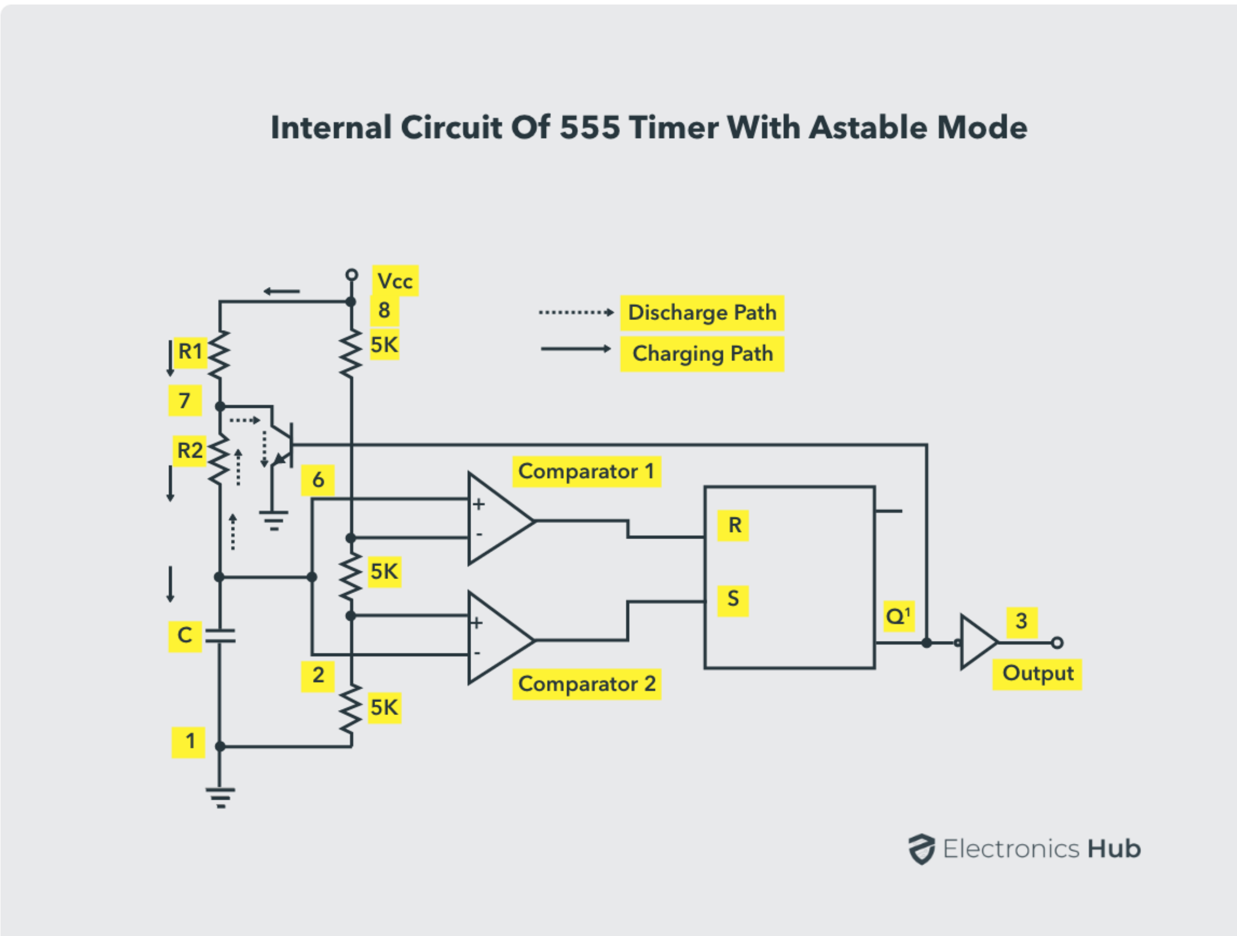


The pins 2 and 6 are connected and hence there is no need for an external trigger pulse. It will self trigger and act as a free running multivibrator (oscillator). The rest of the connections are as follows: pin 8 is connected to supply voltage (V_{CC}). Pin 3 is the output terminal and hence the output is available at this pin. Pin 4 is the external reset pin. A momentary low on this pin will reset the timer. Hence, when not in use, pin 4 is usually tied to V_{CC}.

The control voltage applied at pin 5 will change the threshold voltage level. But for normal use, pin 5 is connected to ground via a capacitor (usually 0.01μF), so the external noise from the terminal is filtered out. Pin 1 is ground terminal. The timing circuit that determines the width of the output pulse is made up of R_1, R_2 and C.

Operation

The following schematic depicts the internal circuit of the IC 555 operating in astable mode. The RC timing circuit incorporates R_1, R_2 and C.



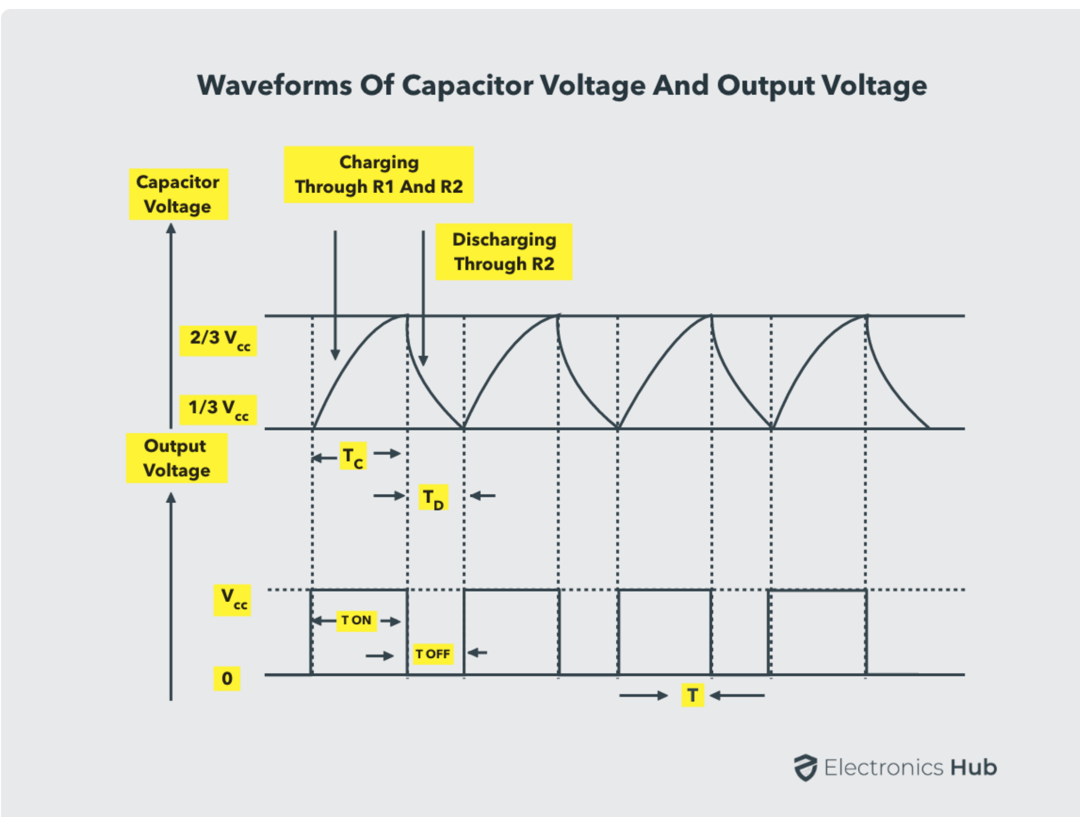
Initially, on power-up, the flip-flop is RESET (and hence the output of the timer is low). As a result, the discharge transistor is driven to saturation (as it is connected to Q'). The capacitor C of the timing circuit is connected at Pin 7 of the IC 555 and will discharge through the transistor. The output of the timer at this point is low. The voltage across the capacitor is nothing but the trigger voltage. So, while discharging, if the capacitor voltage becomes less than 1/3 V_{cc}, which is the reference voltage to trigger comparator

(comparator 2), the output of the comparator 2 will become high. This will SET the flip-flop and hence the output of the timer at pin 3 goes to HIGH.

This high output will turn OFF the transistor. As a result, the capacitor C starts charging through the resistors R_1 and R_2. Now, the capacitor voltage is same as the threshold voltage (as pin 6 is connected to the capacitor resistor junction). While charging, the capacitor voltage increases exponentially towards V_{cc} and the moment it crosses 2/3 V_{cc}, which is the reference voltage to threshold comparator (comparator 1), its output becomes high.

As a result, the flip-flop is RESET. The output of the timer falls to LOW. This low output will once again turn on the transistor which provides a discharge path to the capacitor. Hence the capacitor C will discharge through the resistor R_2. And hence the cycle continues.

Thus, when the capacitor is charging, the voltage across the capacitor rises exponentially and the output voltage at pin 3 is high. Similarly, when the capacitor is discharging, the voltage across the capacitor falls exponentially and the output voltage at pin 3 is low. The shape of the output waveform is a train of rectangular pulses. The waveforms of capacitor voltage and the output in the astable mode are shown below.



While charging, the capacitor charges through the resistors R_1 and R_2. Therefore the charging time constant is $(R_1 + R_2)$ C as the total resistance in the charging path is $R_1 + R_2$. While discharging, the capacitor discharges through the resistor R_2 only. Hence, the discharge time constant is R_2C.

Duty Cycle

The charging and discharging time constants depends on the values of the resistors R1 and R2. Generally, the charging time constant is more than the discharging time constant. Hence the HIGH output remains longer than the LOW output and therefore the output waveform is not symmetric. Duty cycle is the mathematical parameter that forms a relation between the high output and the low output. Duty Cycle is defined as the ratio of time of HIGH output i.e., the ON time to the total time of a cycle.

If TON is the time for high output and T is the time period of one cycle, then the duty cycle D is given by:

$$D = T_{ON} / T$$

Therefore, percentage Duty Cycle is given by:

$$\%D = (T_{ON} / T) * 100$$

T is sum of T_{ON} (charge time) and T_{OFF} (discharge time).

The value of T_{ON} or the charge time (for high output) T_C is given by:

$$T_{ON} = T_C = 0.693 * (R_1 + R_2)\ C$$

The value of T_{OFF} or the discharge time (for low output) T_D is given by

$$T_{OFF} = T_D = 0.693 * R_2C$$

Therefore, the time period for one cycle T is given by

$$T = T_{ON} + T_{OFF} = T_C + T_D$$

$$T = 0.693 * (R_1 + R_2) C + 0.693 * R_2C$$

$$T = 0.693 * (R_1 + 2R_2) C$$

Therefore, $\%D = (T_{ON}/ T) * 100$

$$\%D = (0.693 * (R_1 + R_2) C)/(0.693 * (R_1 + 2R_2) C) * 100$$

$$\%D = ((R_1 + R_2)/(R_1 + 2R_2)) * 100$$

If $T = 0.693 * (R_1 + 2R_2) C$, then the frequency f is given by

$$f = 1 / T = 1 / 0.693 * (R_1 + 2R_2) C$$

$$f = 1.44/((R_1 + 2R_2) C) \text{ Hz}$$

Selection of R_1, R_2 and C_1

The Selection of values of R_1, R_2 and C_1 for different frequency range are as follow:

R_1 and R_2 should be in the range 1KΩ to 1MΩ. It is best to Choose C_1 first (because capacitors are available in just a few values and are usually not adjustable, unlike resistors) as per the frequency range from the following table.

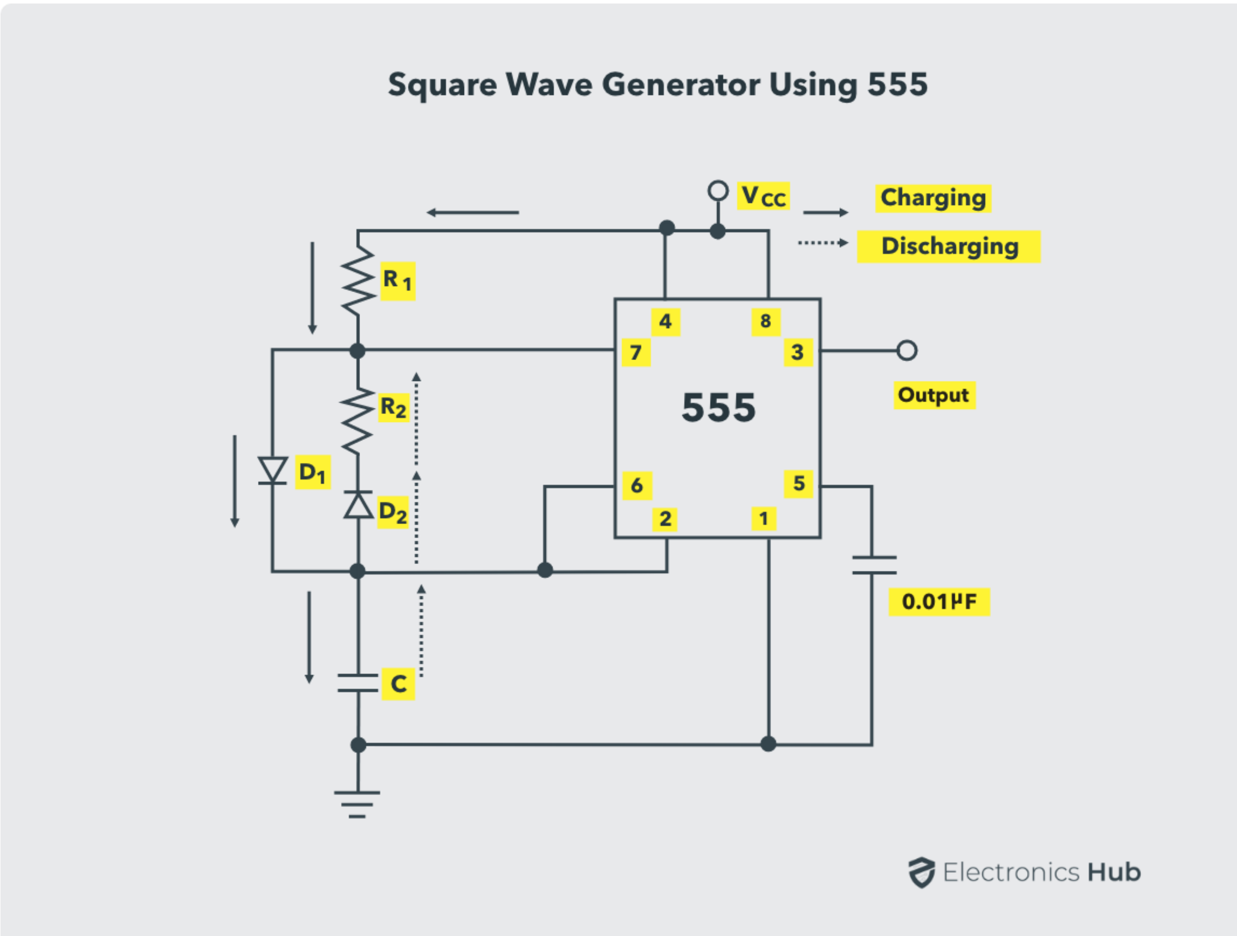
Choose R2 to give the frequency (f) you require.

$R_2 = 0.7 /(f \times C_1)$

Square Wave Generation
The duty cycle of an astable multivibrator is always greater than 50%. A square wave is obtained as the output of an astable multivibrator when the duty cycle is 50% exactly. Duty

cycle of 50% or anything less than that is not possible with the IC 555 as an astable multivibrator mentioned above. Some modifications are to be made to the circuit.

The modification is to add two diodes. One diode in parallel to the resistor R_2 with cathode connected to the capacitor and another diode in series with the resistor R_2 with anode connected to the capacitor. By adjusting the values of the resistors R_1 and R_2, a duty cycle in the range of 5% to 95% can be obtained including the square wave output. The circuit for square wave generation is shown below.



In this circuit, while charging, the capacitor charges through R_1 and D_1 by passing R_2. While discharging, it discharges through D_2 and R_2.

Therefore, the charging time constant is $T_{ON} = T_C$ and is given by:

$$T_{ON} = 0.693 * R_1 * C$$

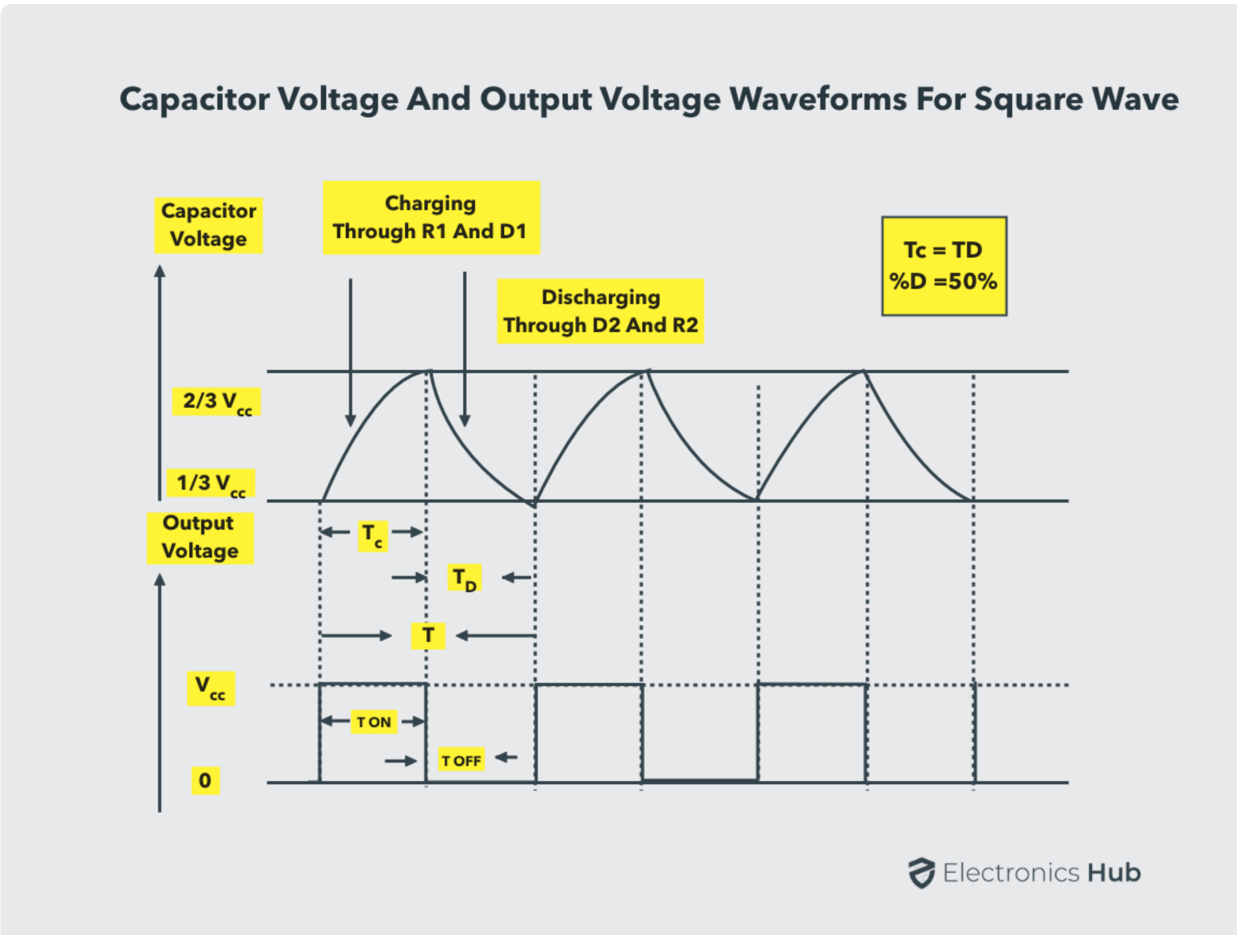
And the discharging time constant $T_{OFF} = T_D$ is given by:

$$T_{OFF} = 0.693 * R_2 * C$$

Therefore, the duty cycle D is given by:

$$D = R_1/(R_1 + R_2)$$

In order to get a square wave, the duty cycle can be made 50% by making the values of R_1 and R_2 equal. The waveforms of the square wave generator are shown below.



A duty cycle of less than 50% is achieved when the resistance of R_1 is less than that of R_2. Generally, this can be achieved by using potentiometers in place of R_1 and R_2. Another circuit of square wave generator can be constructed from the astable multivibrator without using any diodes. By placing the resistor R_2 between pins 3 and 2 i.e., output terminal and trigger terminal.

Buck converter circuit: