Digital Electronics

555 Timer

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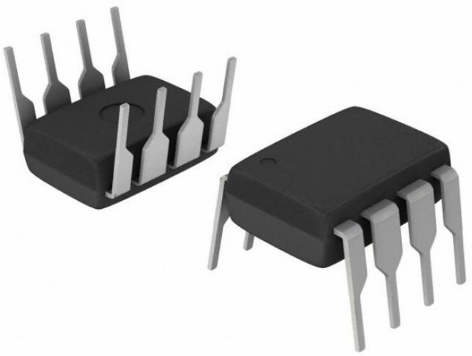
What is IC 555?

- The IC 555 timer is a one type of chip used in different applications like an oscillator, pulse generation, timer.



- The operating range of this IC ranges from 4.5V -15V DC supply.

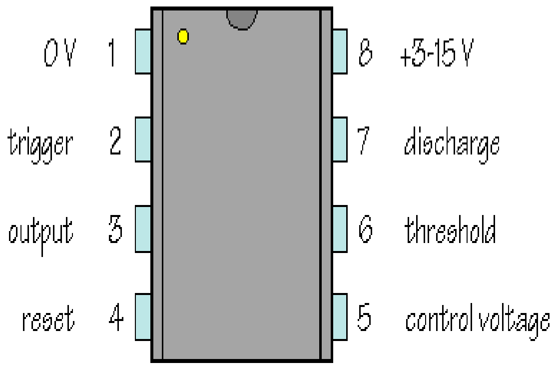
- The functional parts of the 555 timer IC include flip-flop, voltage divider and a comparator.

- The main function of this IC is to generate an accurate timing pulse.

Pin configuration of IC 555

- **GND Pin:** Pin-1 is a GND pin which is used to supply a zero voltage to the IC.
- **Trigger Pin:** Pin-2 is a trigger pin which is used to convert the FF from set to reset. The output of the timer depends on the amplitude of the external trigger pulse that is applied to the trigger pin.
- **Output Pin:** Pin-3 is an output pin.
- **Reset Pin:** Pin-4 is a Reset pin. When the negative pulse is applied to this pin to disable or reset, a false triggering can be neglected by connecting to VCC.

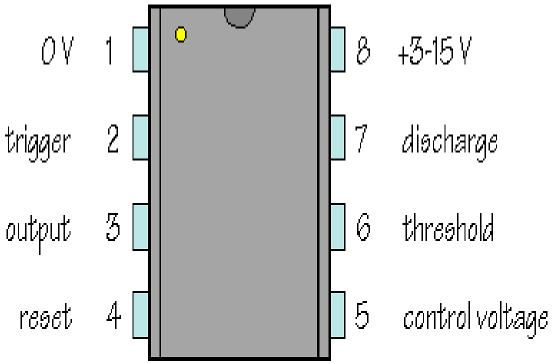
DIP chip (Dual-Inline package)



Pin configuration of IC 555 (*contd…*)

- **Control Voltage Pin:** Pin-5 is the control voltage pin used to control the pulse width of the output waveform and also the levels of threshold and trigger. When an external voltage is applied to this pin, then the output waveform will be modulated
- **Threshold Pin:** Pin-6 is the threshold pin, when the voltage is applied to threshold pin, then it contrasts with a reference voltage. The set state of the FF can be depends on the amplitude of this pin.
- **Discharge Pin:** Pin-7 is the discharge pin, when the output of the open collector discharges a capacitor between the intervals, then it toggles the output from high to low.
- **Supply Terminal:** Pin-8 is the voltage supply pin which is used to supply the voltage to the IC with respect to the ground terminal.

DIP chip (Dual-Inline package)



Basic Operation of IC 555

- When the normally HIGH trigger input momentarily goes below 1/3 Vcc, the output of comparator B switches from LOW to HIGH and sets the S-R latch (Q=1). causing the output (pin 3) to go HIGH and turning the discharge transistor Q1 off.

- When the LOW threshold input goes above 2/3 Vcc and causes the output of comparator A to switch from LOW to HIGH. This resets the latch (Q=0), causing the output (pin 3) to go back LOW and turning the discharge transistor on.

- Note: The trigger and threshold inputs are controlled by external components connected to produce either monostable or astable action.

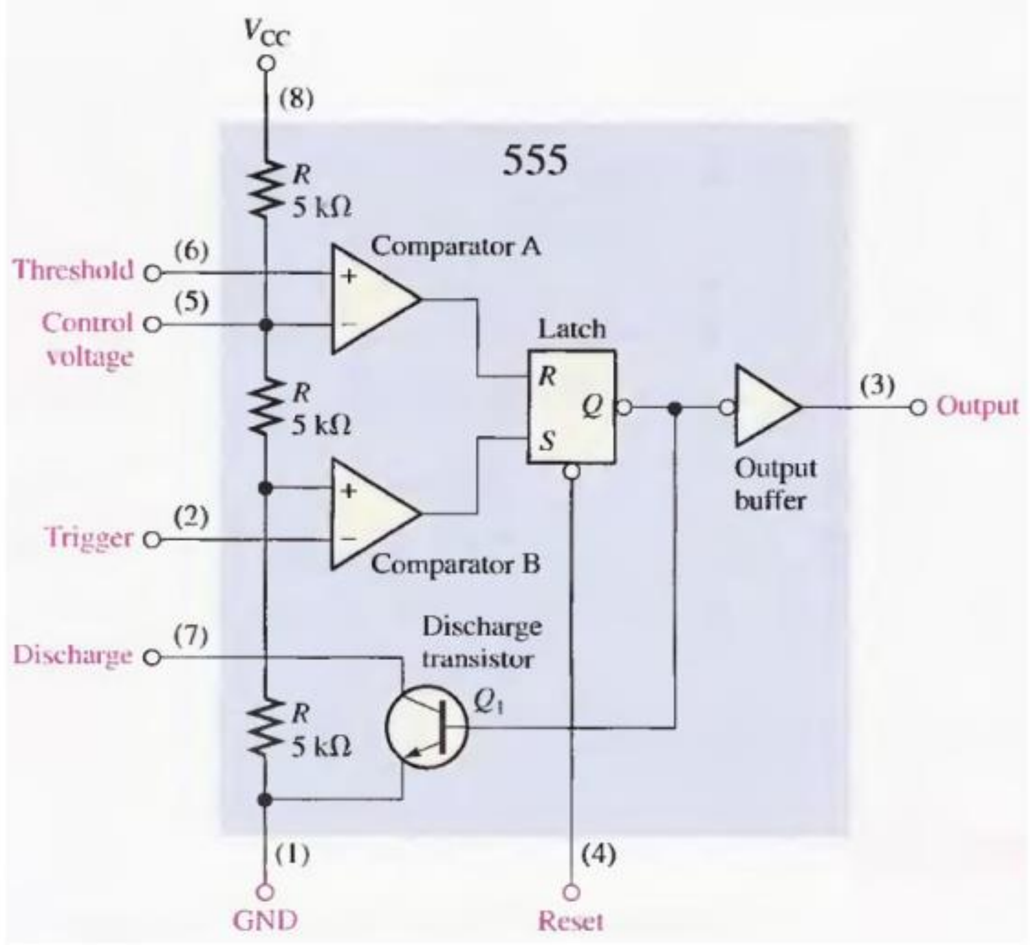


Fig 1. Internal functional diagram of a 555 timer.

Modes of IC 555 timer

- Time Delay Mode

- In the time delay mode, the delay is controlled by one external resistor and capacitor.
- Also Known as **Monostable (One-shot) mode.**

Example: Turn a light ON in a delayed amount of time. (Just turn ON or OFF once)

- Oscillator Mode

- In the oscillator mode, the frequency of oscillation are controlled with two external resistors and one capacitor.
- Also known as **Astable mode.**

Example: Can make a light flash a specific rate. (Can turn ON and OFF repeatedly)

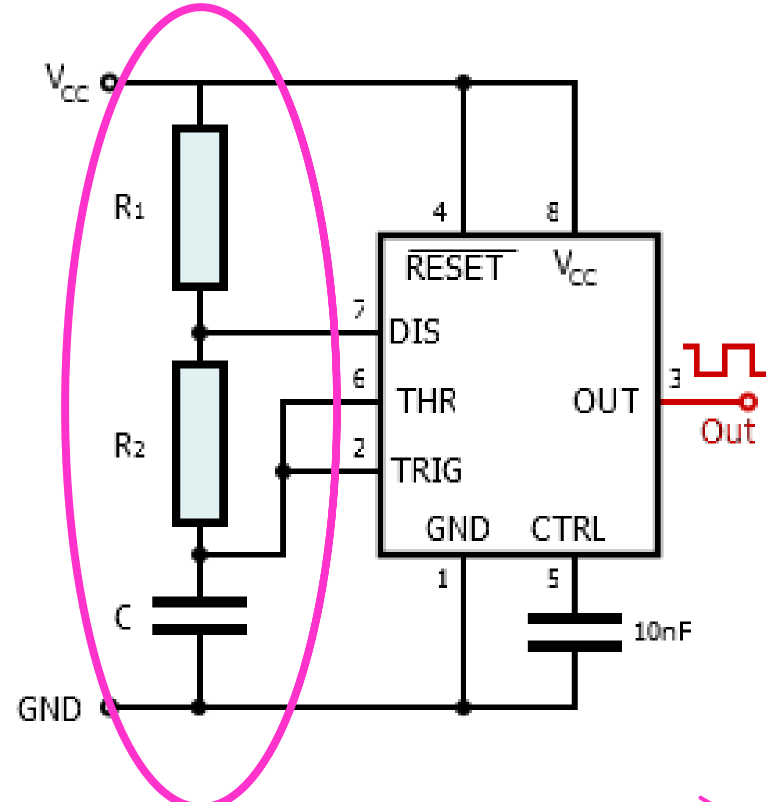
- Another mode is Bistable Mode

IC 555 timer : *Astable Mode*

Astable multivibrator mode schematic

Notice:

- 2 resistors
- 1 capacitor
- OUTPUT is square wave pulses



IC 555 timer : *Astable Mode*

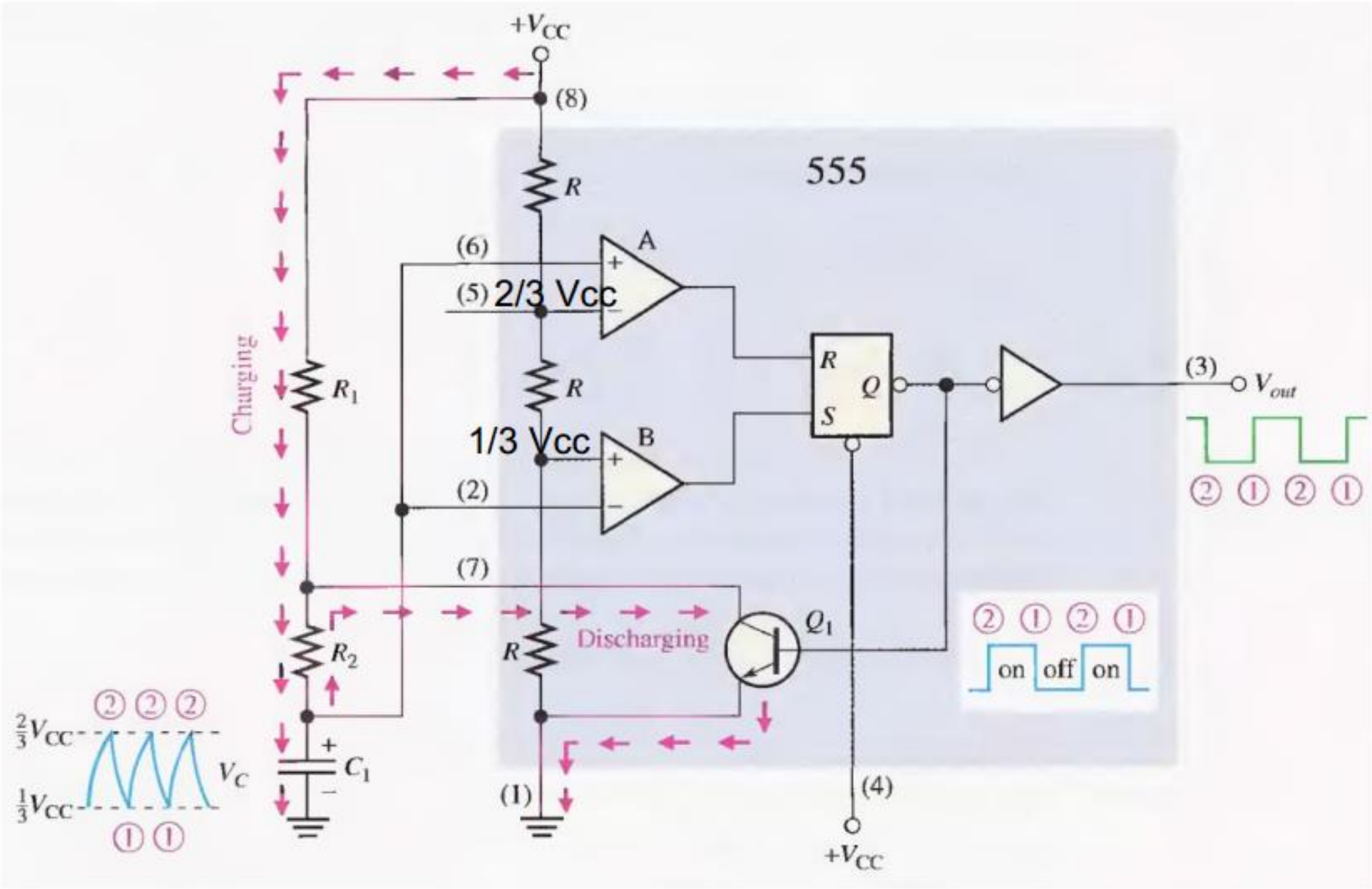


Fig. Operation of the 555 timer in the astable mode.

IC 555 timer : *Astable Mode*

<u>Operation</u>

- Initially, when the power is just turned on, the capacitor (C1) remain '**Uncharged'** and thus the trigger (pin 2) and threshold (pin 6) is at **0 V**. So, Vout (comp. A) = 0 and Vout (comp. B) = 1. That's why Q1 is **OFF.**

- Now, **C1** begins **charging** through R1 and R2, indicated in Figure. When, C1 is just above 2/3Vcc then Vout= (comp A)=1 and Vout= (comp B)=0 which Resets the latch (Q=0).

- At this state **Q1** turns **ON** and creates a **discharging** path as shown in the figure. When C1 discharge it causes Vout (comp. A)=0 and when C1 discharges down to 1/3Vcc then Vout (comp. B)=1.

- This again Sets latch and turning off Q1 again. Another charging cycle begins and the entire process repeats.

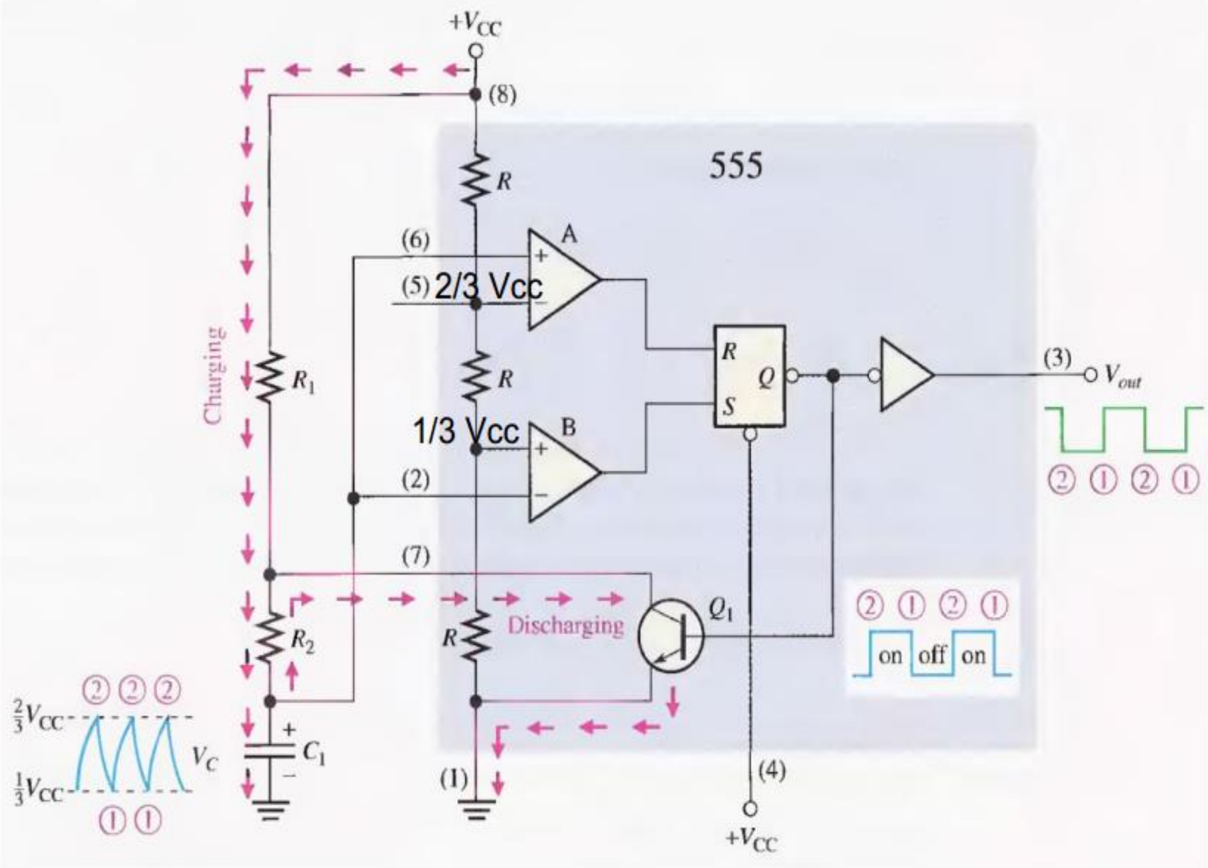
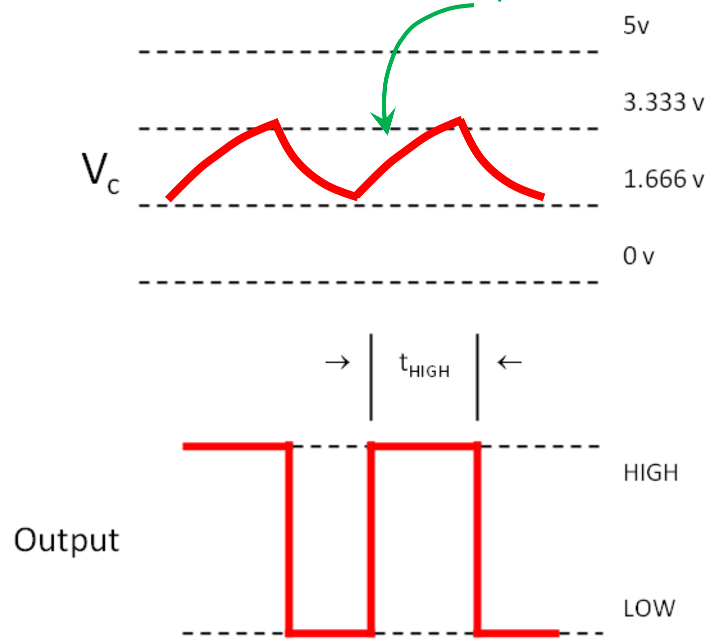


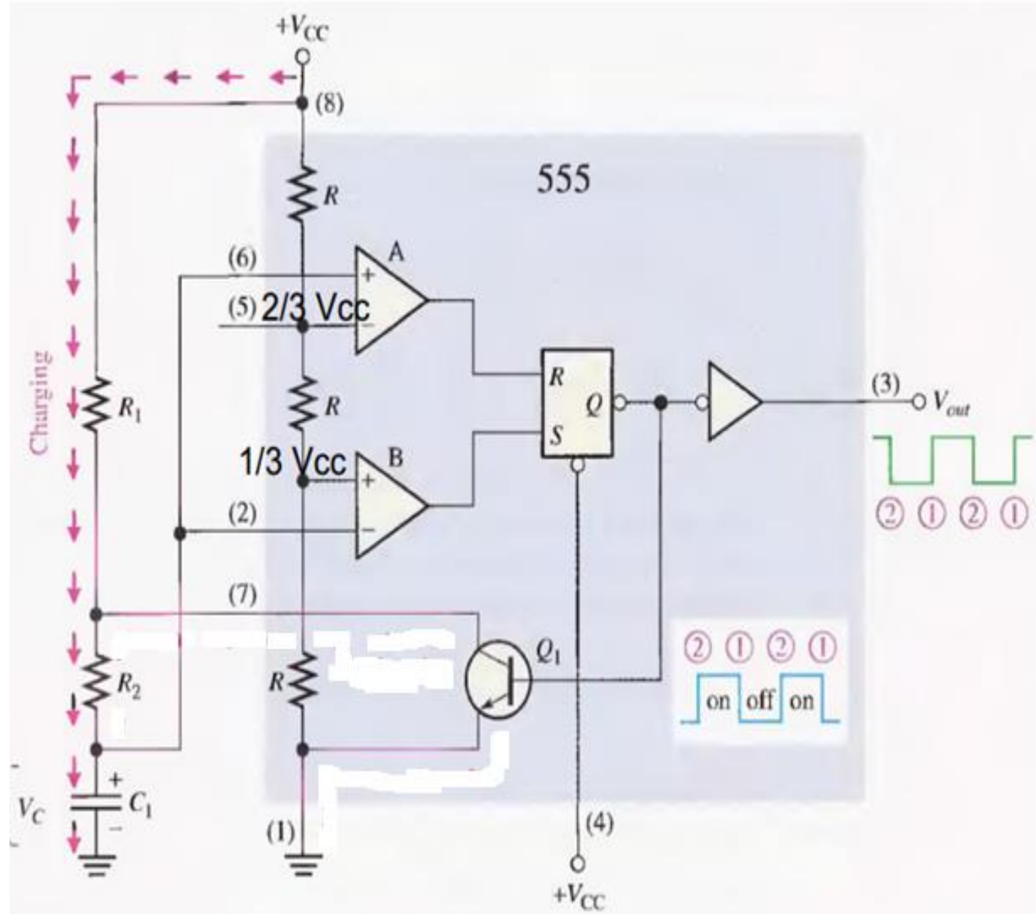
Fig. Operation of the 555 timer in the astable mode.

IC 555 timer : *Astable Mode*

t_{HIGH} : Calculations for the Oscillator's HIGH Time

THE OUTPUT IS HIGH WHILE THE CAPACITOR IS CHARGING THROUGH $R_A + R_B$.



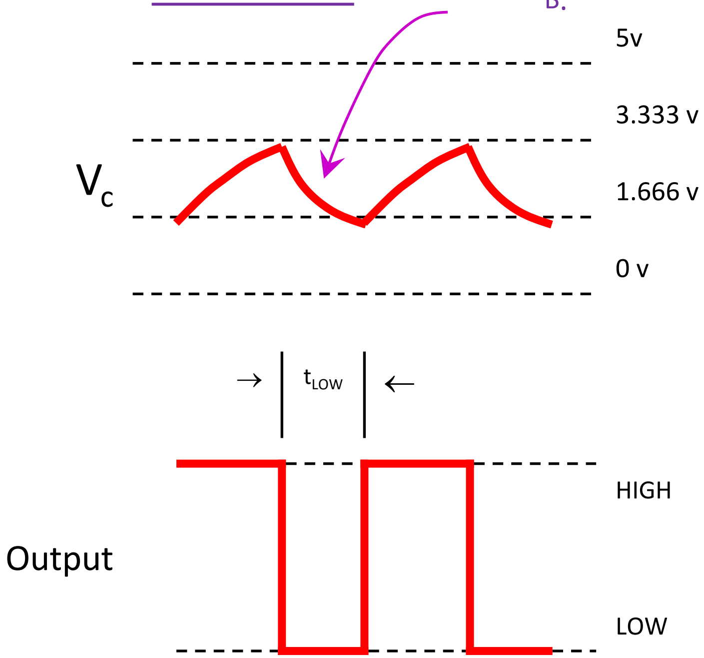


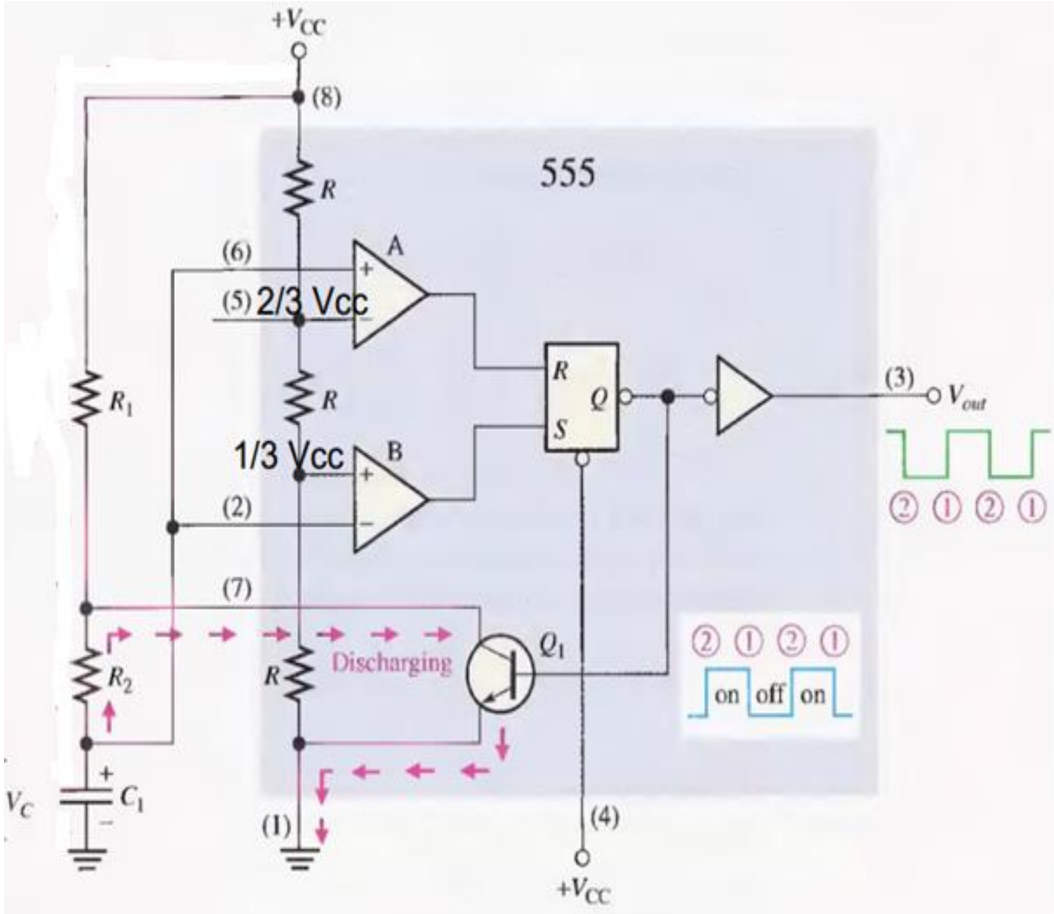
$$t_{HIGH} = 0.693(R_A + R_B)C$$

IC 555 timer : *Astable Mode*

t_{LOW} : Calculations for the Oscillator's LOW Time

THE OUTPUT IS LOW WHILE THE CAPACITOR IS DISCHARGING THROUGH R_{B}.



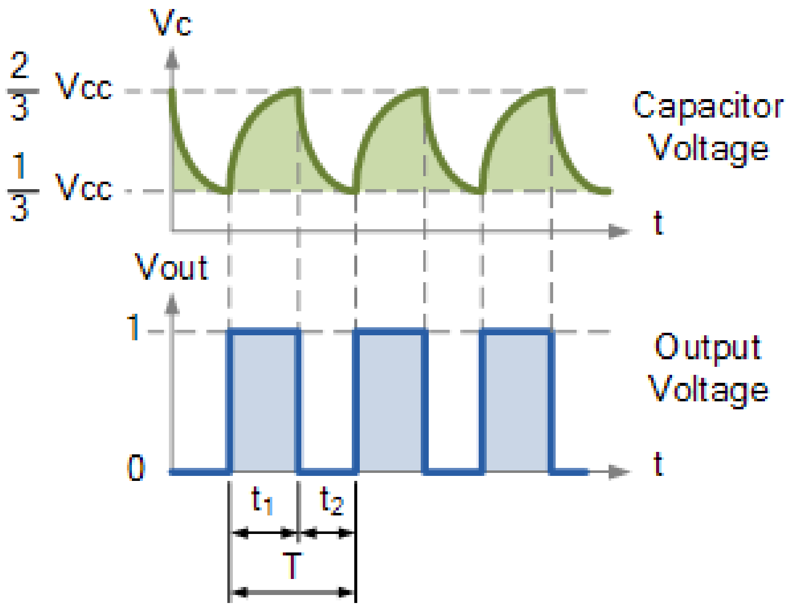


$$t_{LOW} = 0.693 R_B C$$

IC 555 timer : *Astable Mode*

Time Period:

The Period is the total time of an on/off cycle and depends on the values of R_A, R_B, and C



$$t_{HIGH} = 0.693(R_A + R_B)C$$

$$t_{LOW} = 0.693\,R_B C$$

$$T = t_{HIGH} + t_{LOW}$$

$$T = [0.693(R_A + R_B)C] + [0.693\,R_B C]$$

$$T = 0.693(R_A + 2R_B)\mathrm{C}$$

Notes:

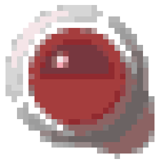
•The value 0.693 is a factor associated with the charge/discharge cycle of the 555 timer.

IC 555 timer : *Astable Mode*

<u>Frequency :</u>

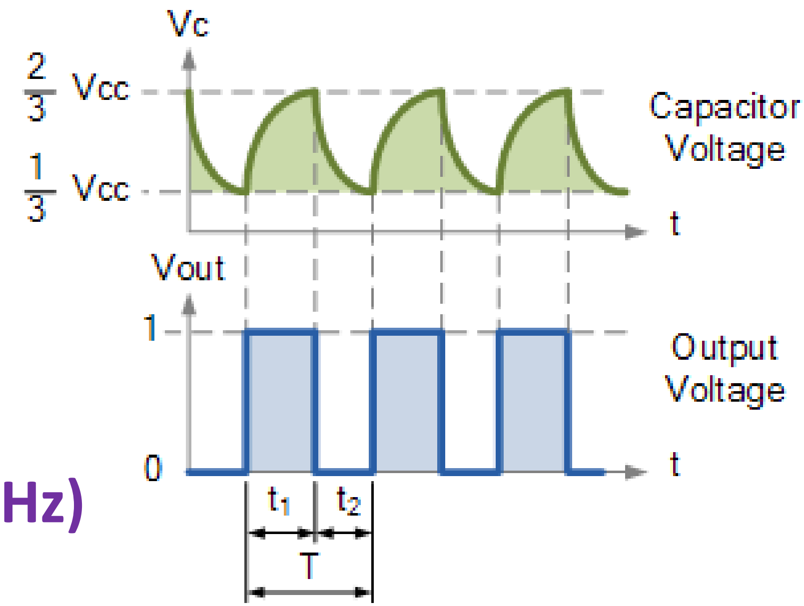
The frequency of an oscillation (or anything that exhibits a repeating pattern) is inversely proportional to the period

$$F = \frac{1}{T}$$



Unit of Measure:

cycles/second = Hertz **(Hz)**



$$F = \frac{1}{0.693\left(R_A + 2R_B\right)C}$$

Mathematical Problem

- **Design an oscillator for a frequency of 200Hz with a duty cycle of 78%. Determine time period, high & low time, R_B and R_A (assume C=10µF)**

1. Determine Period (T):

$$T = \frac{1}{F} = \frac{1}{200Hz} = 0.005s$$

2. Determine T_H and T_L:

$$T_H = 78\% \bullet 0.005s = 0.0039s = 3.9ms$$
$$T_L = 22\% \bullet 0.005s = 0.0011s = 1.1ms$$

Mathematical Problem (*contd…*)

3. Determine R_B by using the T_L equation:

$$T_L = 0.693 R_B C$$

$$1.1\text{ms} = 0.693 \bullet R_B \bullet 10\mu\text{F}$$

$$R_B = 158.7\Omega$$

4. Determine the value of R_A:

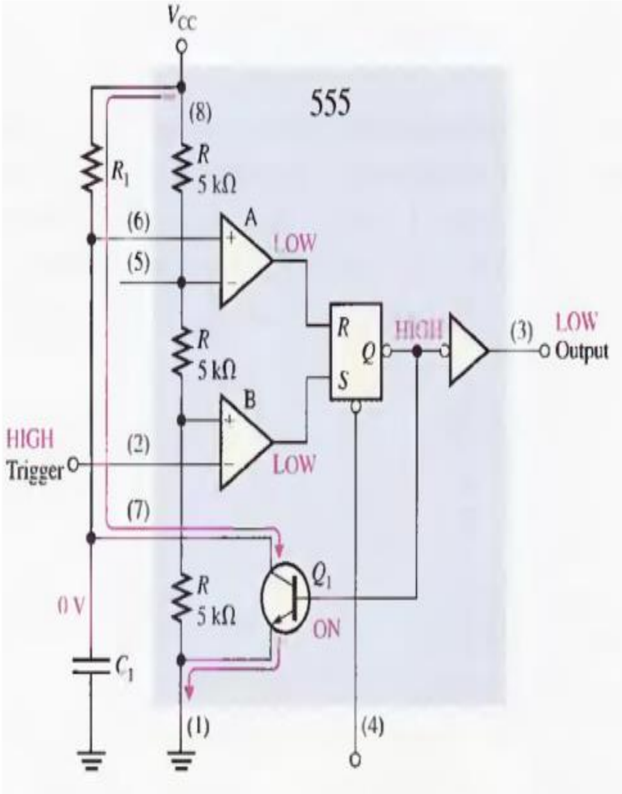
$$T_H = 0.693(R_A + R_B)C$$

$$3.9\text{ms} = 0.693(R_A + 158.7\Omega)10\mu\text{F}$$

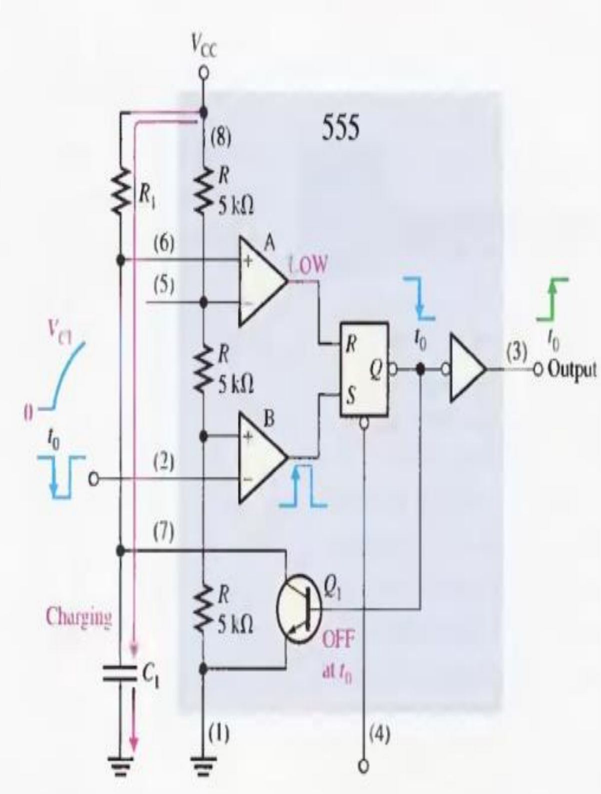
$$562.8\Omega = R_A + 158.7\Omega$$

$$R_A = 404.1\Omega$$

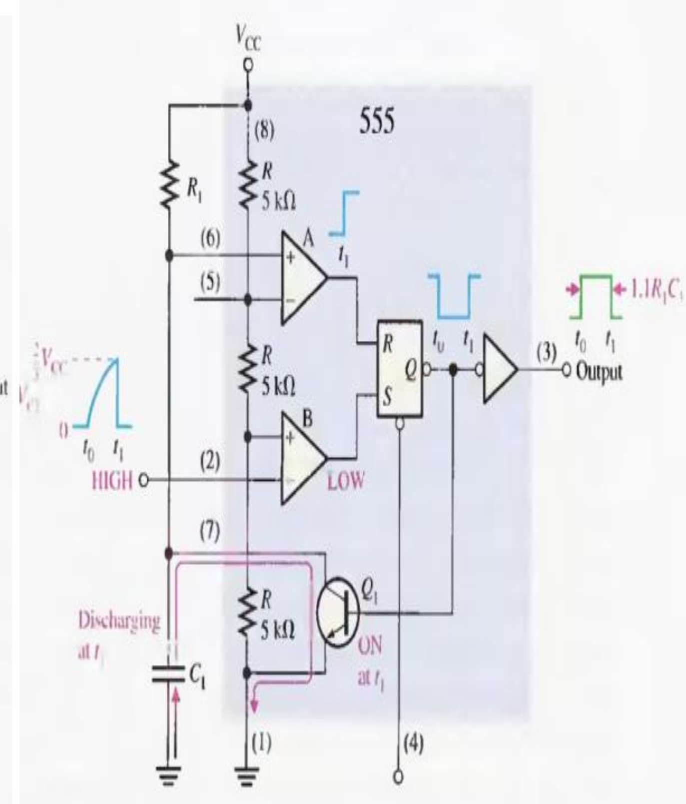
IC 555 timer : *Monostable Mode*



(a) Prior to triggering. (The current path is indicated by the red arrow.



(b) When triggered

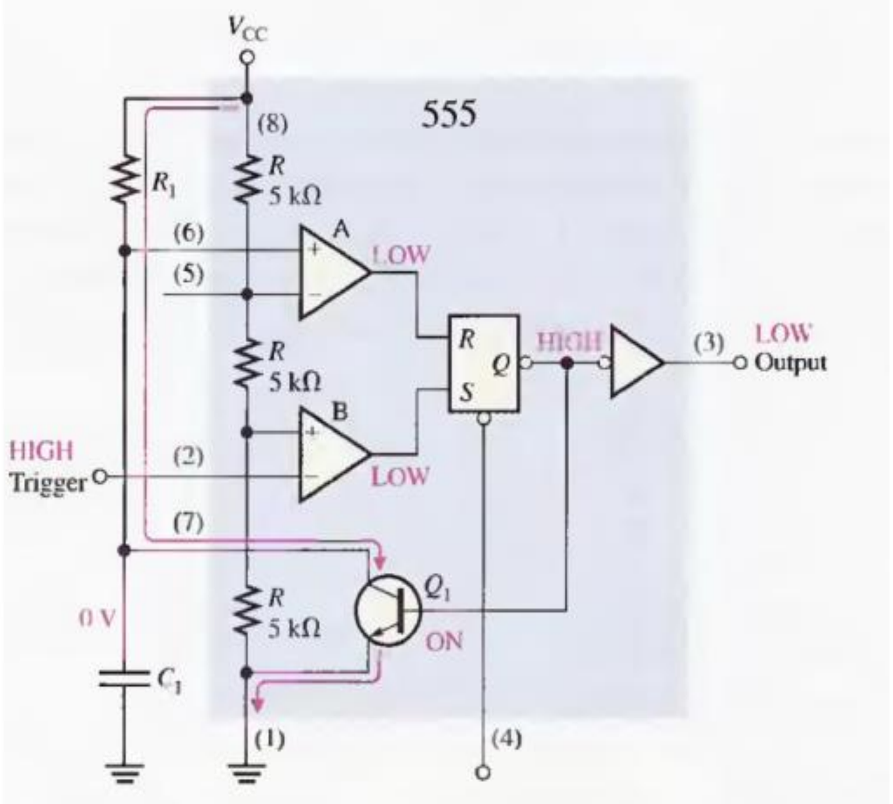


(c) At end of charging interval

IC 555 timer : *Monostable Mode*

Before a trigger pulse is applied, the output is LOW (***Stable off-state***) and the discharge transistor Q1 is ON, keeping C1 discharged as shown in Figure.

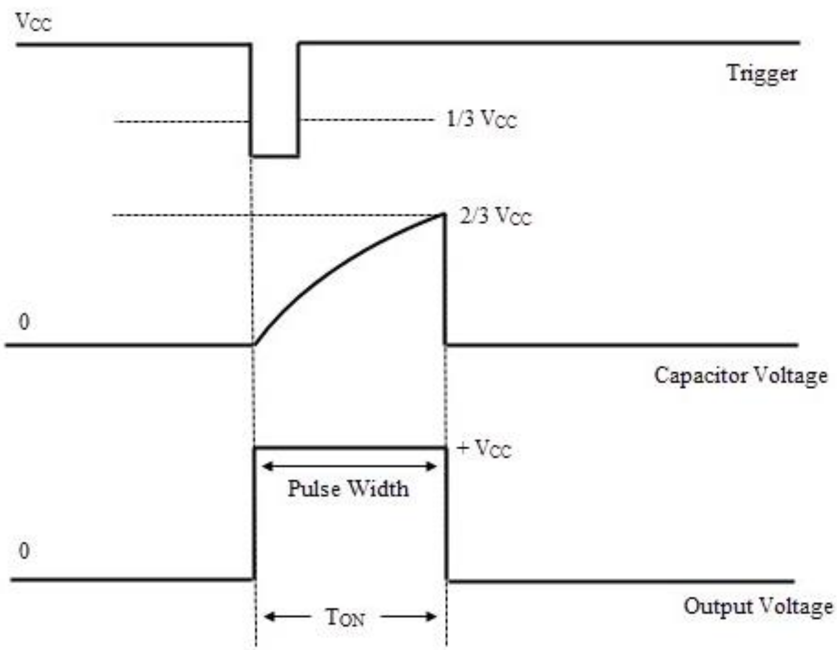
Note: Before a trigger pulse, it is equal to Vcc .

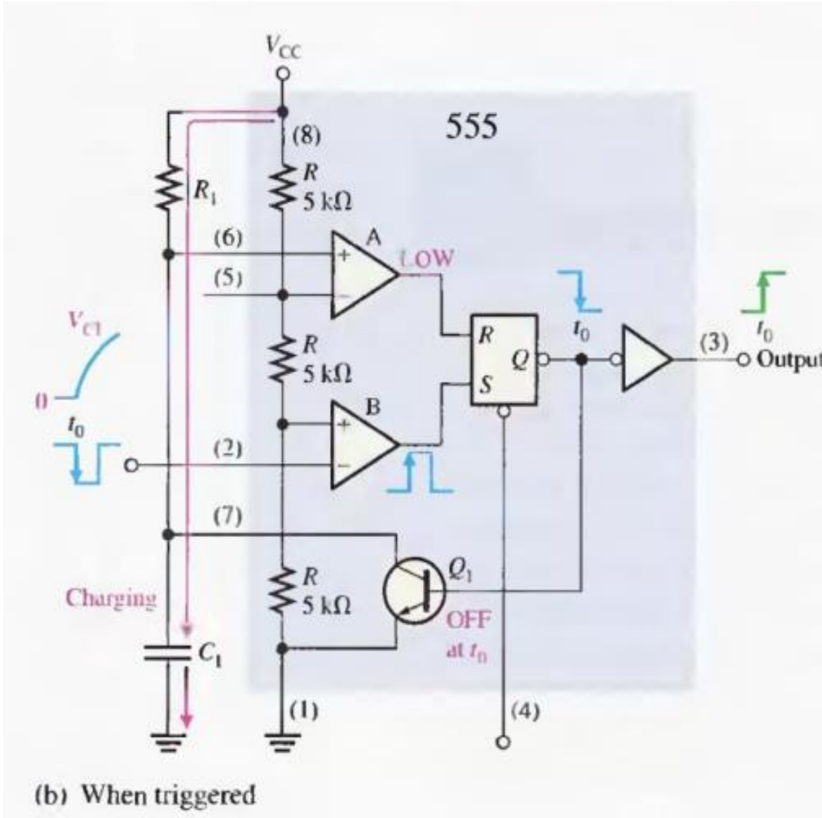


(a) Prior to triggering. (The current path is indicated by the red arrow.)

IC 555 timer : *Monostable Mode*

At time, t_0 a negative going triggering pulse is applied and it becomes less than 1/3Vcc; then (+ve) i/p > (-ve) i/p for comp. B.





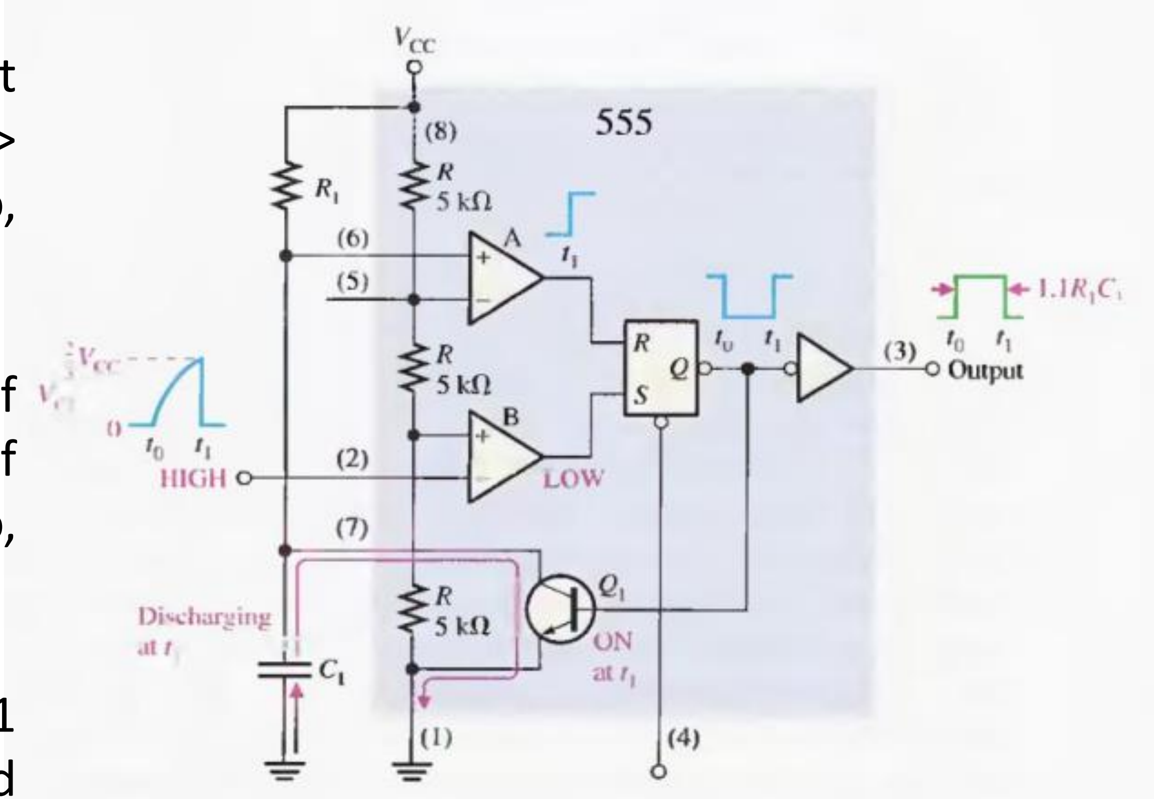
So, **Comp. B = 1** which makes Output = High. Q1 is off and allowing C1 to charge through R1 as shown in Figure.

IC 555 timer : *Monostable Mode*

At time, t_1 when C1 is just above 2/3 Vcc then (+ve) i/p > (-ve) i/p for comp. A. So, **Comp. A = 1.**

At the same time, (-ve) i/p of comp. B (**HIGH**) > (+ve) i/p of comp. B (1/3 of Vcc). So, **comp. B = 0.**

Thus **o/p = 0** (LOW) at t1 state. This turns on Q1 and helps C1 to discharge.



(c) At end of charging interval

- The pulse width of the output is determined by the time constant of R_1 and C_1 :

$$\mathbf{t_w = 1.1\ R_1\ C_1}$$

Thank You