

# Rajshahi University of Engineering And Technology

## Assignment on 555 Timer

**Course name:** Analog Electronics

**Course code:** EEE 2151

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Problem 1: Design a square wave generator using 555 timer. Explain the circuit operation with the required graph, also determine the duty cycle.

Solution:

The 555 timer IC is an integrated circuit used in a variety of timer, delay, pulse generation and oscillator applications.

It also can easily create square waves when in astable mode of operation and also can easily generate square wave signals.

Now, A square wave generator is consisted of a few resistors, capacitors and potentiometers. Now, the design of this generator is given below.

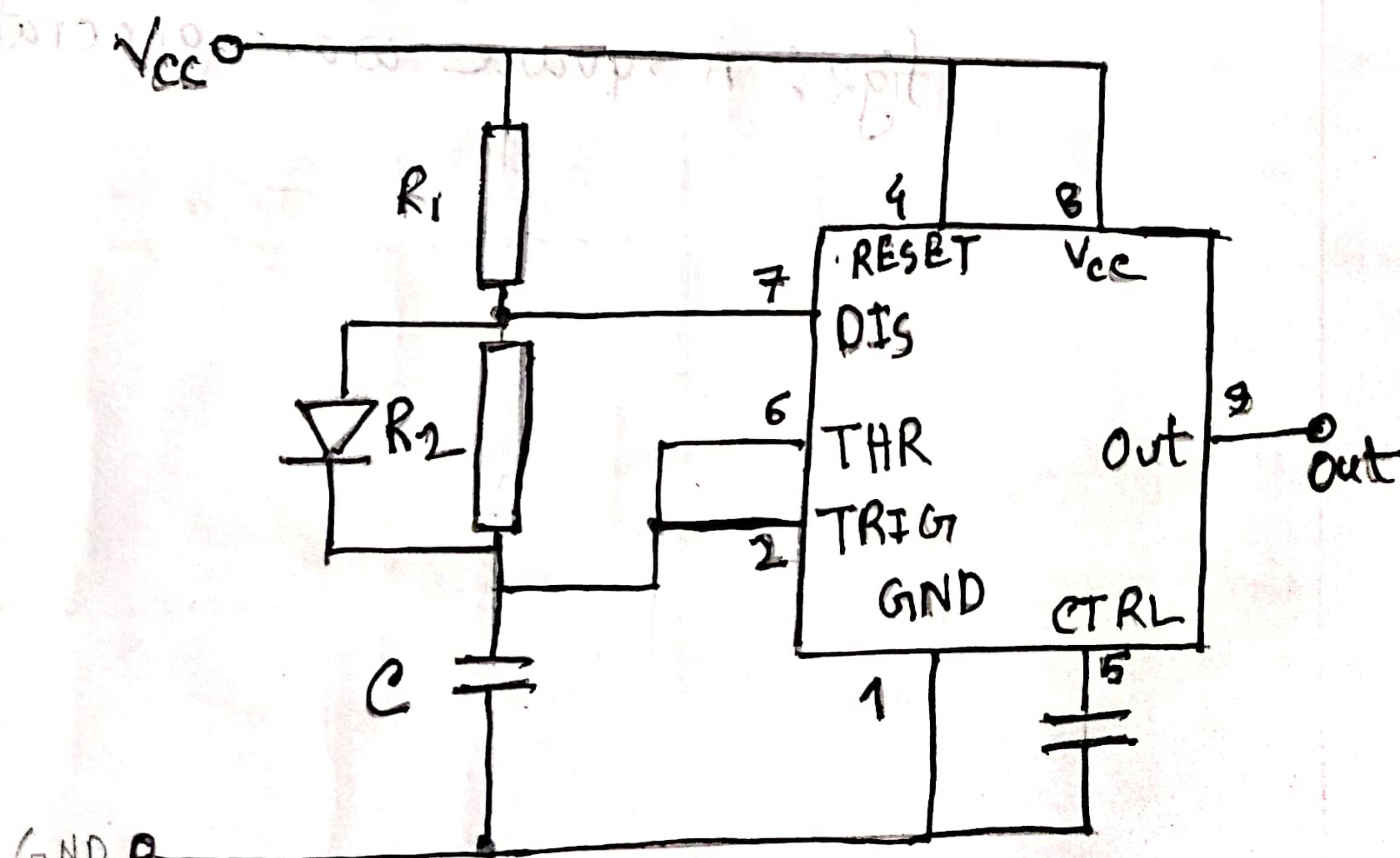


fig 1: A square wave generator circuit using 555 timer

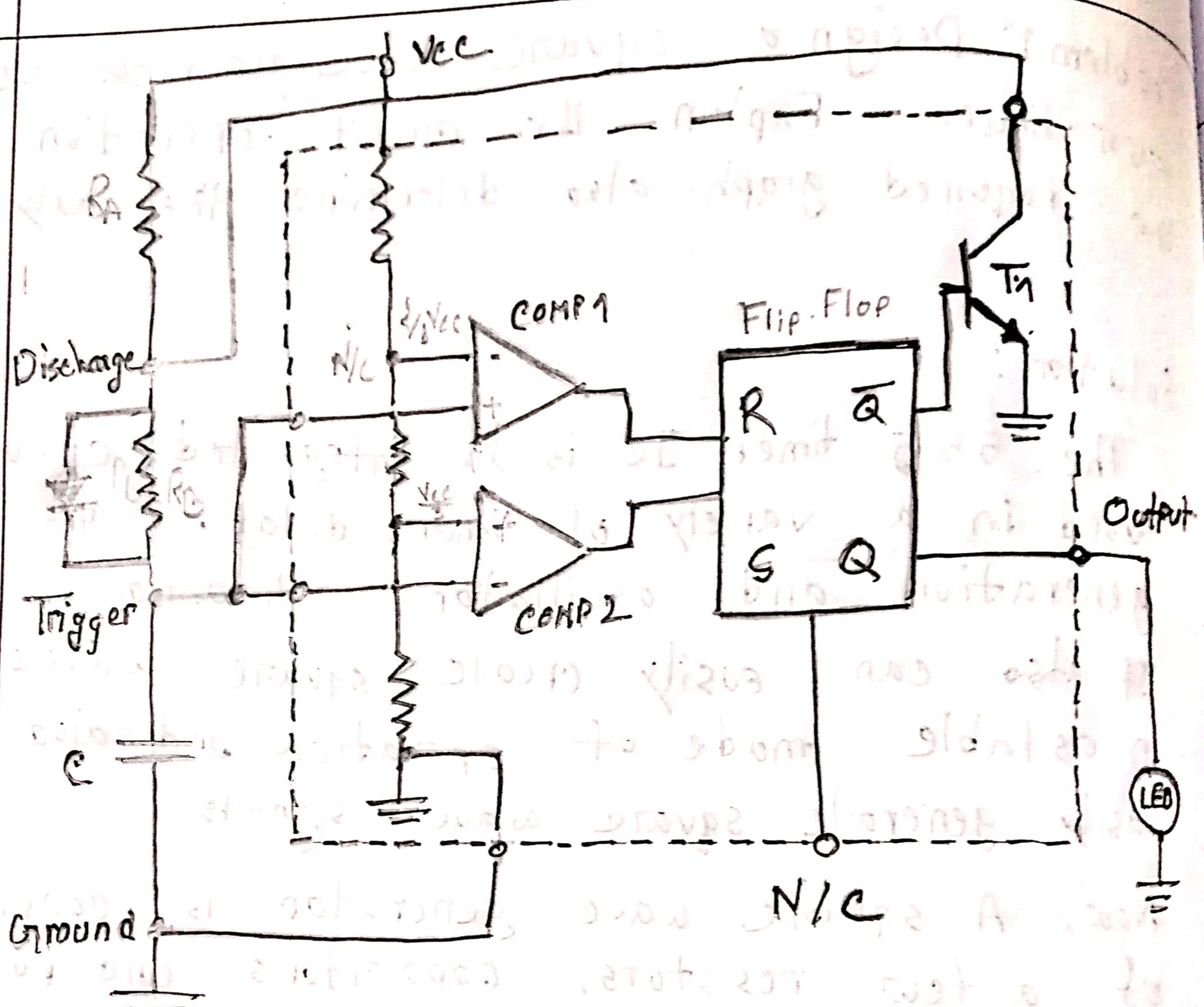
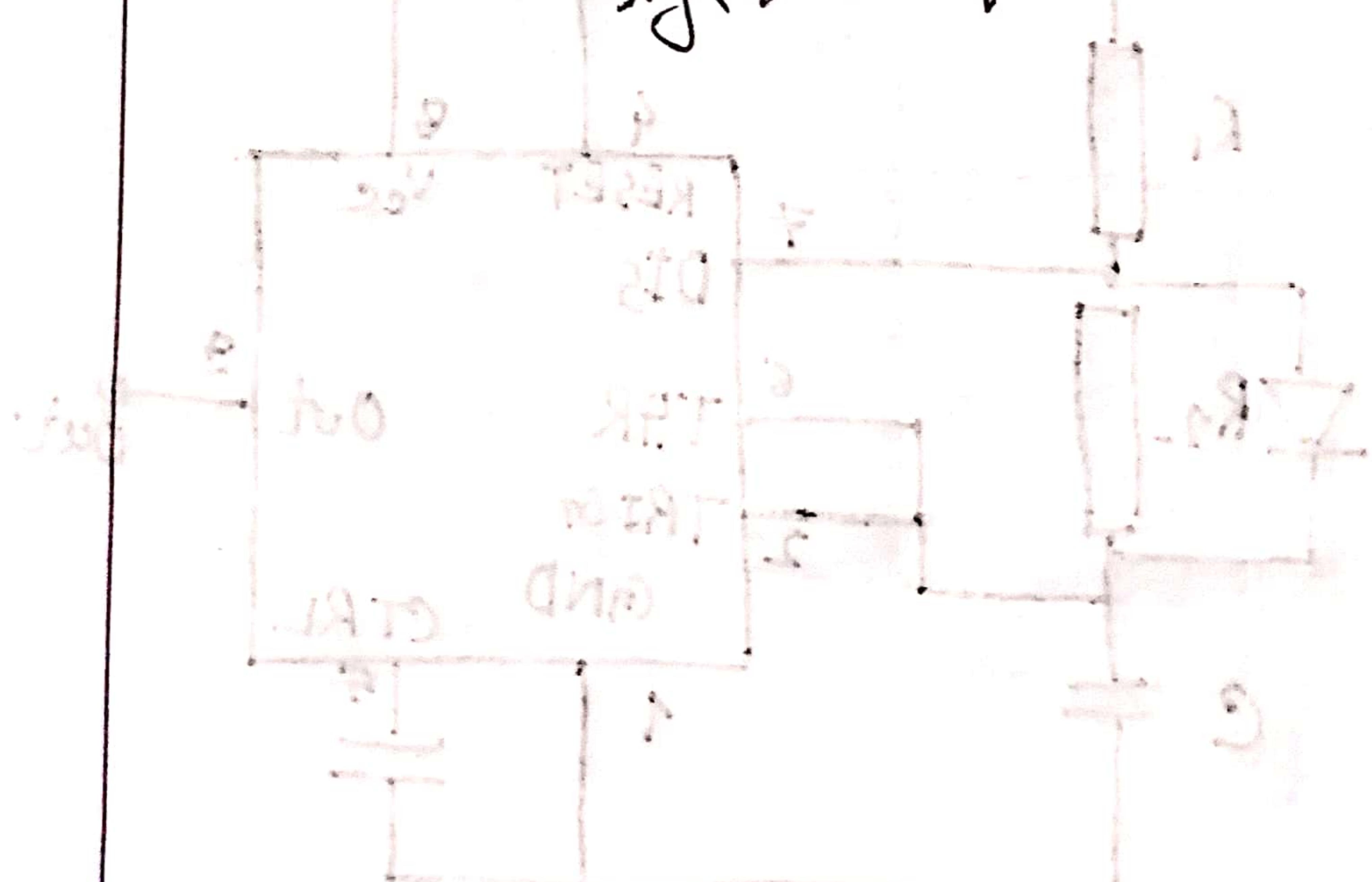


fig: A square wave generator



Circuit operation:

from fig 2, we can see that this circuit is the design of a square wave generator by using 555 timer. But there is a little bit difference and that is, there is a diode which is added in parallel to  $R_B$ . And for this, the duty cycle of this circuit is 50%. So, there are two phases are created. One is when capacitor is charging and another is when capacitor is discharging. Now, the operations which are followed by this square wave generator circuit are given and described below.

phase 1: when capacitor is at initial stage means,  $V_C = 0$ , then  $COMP_1$  will give '0' (zero) ~~digit~~. as the voltage of negative terminal is greater than the voltage of positive terminal. But  $COMP_2$  will give '1' ~~digit~~ because the voltage of negative terminal is less than the voltage of positive terminal. So, the all over output

$Q$  is 1 as the output follows '1'.  
where  $\bar{Q}$  is 0 and bipolar junction  
transistor (BJT) remains in cutoff  
mode.

phase 2: when the charge of capacitor  
increases, the condition of it is

$$\frac{V_{CC}}{3} < \text{charge of capacitor} < \frac{2}{3} V_{CC}$$

So, when this situation occurs, Comp 1  
will give '0' ~~digitally~~ for the  
same reason which is described in phase 1  
and Comp 2 will give '0' in this  
condition because at this moment,  
the voltage of negative terminal  
is greater than the positive terminal.  
For this the output will remain  
same. That means,  $Q=1, \bar{Q}=0$

phase 3: But, when capacitor is in  
the charge of capacitor  $> \frac{2}{3} V_{CC}$   
condition, then, Comp 1 will give  
'1' and Comp 2 because then the  
positive terminal is greater, but

comp 2 will give '0' because the negative terminal is still greater.

so, the final output  $Q$  is '0' as it follows "SET". Then  $\bar{Q} = 1$

This time BJT will be in saturation mode.

Now  $V_{BE} > V_{BE(on)}$  so it will allow more current to flow through the diode.

Now this diode is forward biased so the diode will conduct more current.

Graph:

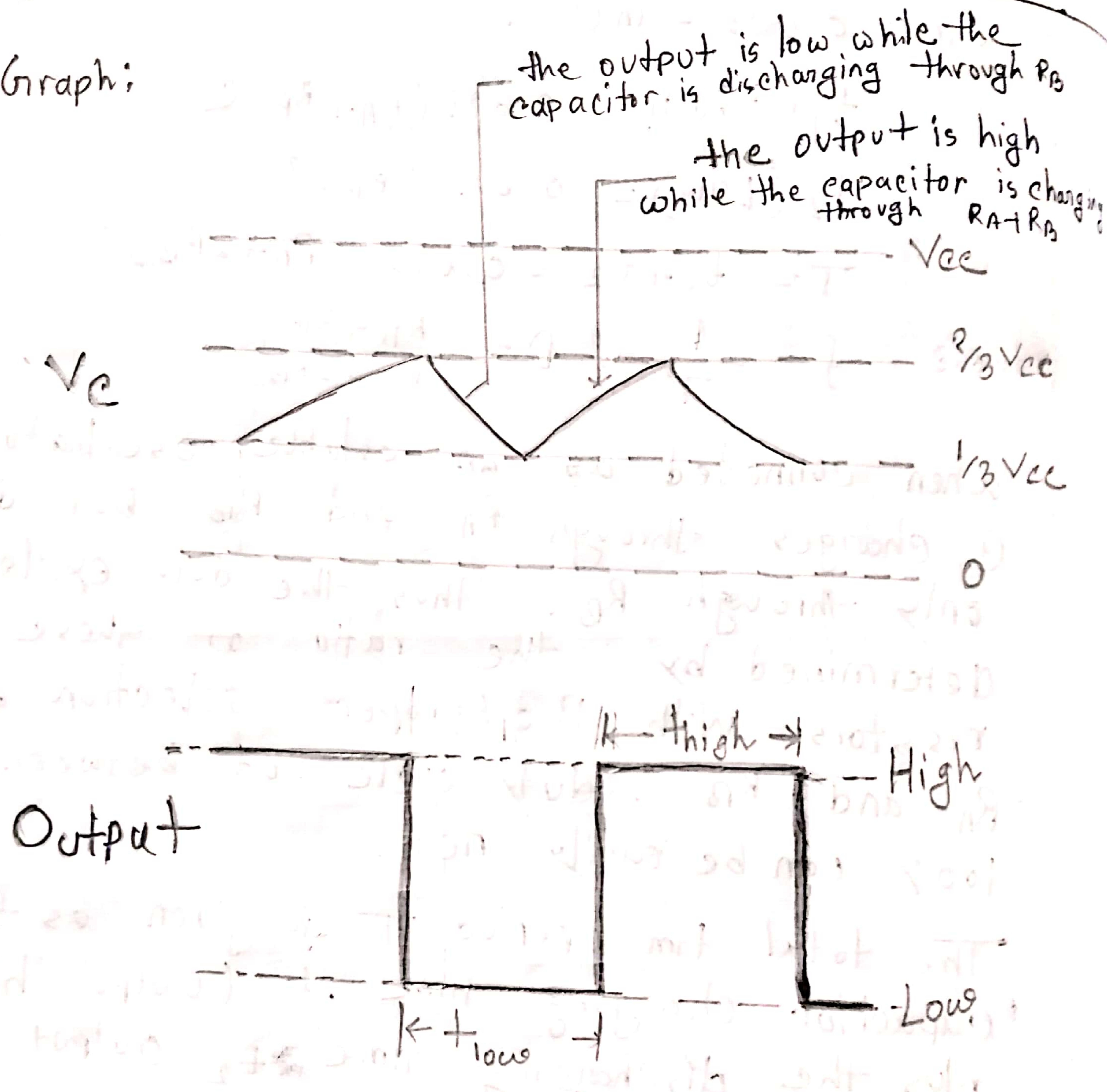


fig: Graph of a square wave generator circuit (555 timer)

## Duty cycle:

We know that,

$$\text{Duty cycle, } D = \frac{\text{ON time}}{\text{ON time} + \text{OFF time}} \times 100$$

and also from the figure 2, we can say that,

$$V_C = V_{\text{final}} - (V_{\text{final}} - V_{\text{initial}}) e^{-t/R_C}$$

Well, here, as  $R_D \ll R_B$ , the charging diode will be 'ON' and the discharging diode will be 'OFF'.

ON time,  $t_1$ :

$$\frac{2}{3}V_{CC} = V_{CC} - \left(V_{CC} - \frac{V_{CC}}{3}\right) e^{-t/(R_A+R_D)C}$$

$$\frac{2}{3}V_{CC} = \frac{V_{CC}}{3} e^{-t/(R_A+R_D)C}$$

$$2 = e^{-t/(R_A+R_D)C}$$

$$\therefore t_1 = 0.693 (R_A+R_D) C$$

OFF time,  $t_2$ :

$$\frac{V_{CC}}{3} = 0 - \left(0 - \frac{2}{3}V_{CC}\right) e^{-t/R_B C}$$

$$\frac{1}{3} = \frac{2}{3} e^{-t/R_B C}$$

$$-t_2 = 0.693 R_B C$$

$$\therefore D = \frac{t_1}{t_1 + t_2} \times 100$$

$$= \frac{0.693 (R_A + R_D) e^{-R_D t_1}}{0.693 (R_A + R_D) e^{-R_D t_1} + 0.693 R_B e^{-R_B t_2}} \times 100$$

$$= \frac{R_A + R_D}{R_A + R_B + R_D} \times 100$$

$$= \frac{R_A}{R_A + R_B} \times 100 \quad [R_D \ll R_B]$$

$$= \frac{R_A}{2R_A} \times 100, \quad [\because R_A = R_B]$$

$$= 50\%$$

$$\rightarrow (0.5 + 0.5) \times \left( \frac{25V}{8} - 25V \right) - 25V = 25V \frac{1}{2}$$

$$\rightarrow (0.5 + 0.5) \times \frac{25V}{8} = 25V \frac{1}{2}$$

$$\rightarrow (0.5 + 0.5) \times 9 = 9$$

$$\rightarrow (0.5 + 0.5) \times 9 = 9$$

$$\rightarrow 2 \times 9 = 18 \quad \text{Ans}$$

Problem 2: Draw the circuit diagram of frequency divider using 555 timer and explain how does it works as frequency divider.

Solution: When the IC 555 is used as a monostable multivibrator, a positive going rectangular pulse is available at the output when a negative going pulse of short duration is applied at the trigger input. By adjusting the time interval  $t$  of the charging of timing circuit the device can be made to work as a frequency divider circuit. The circuit diagram of this circuit is drawn below.

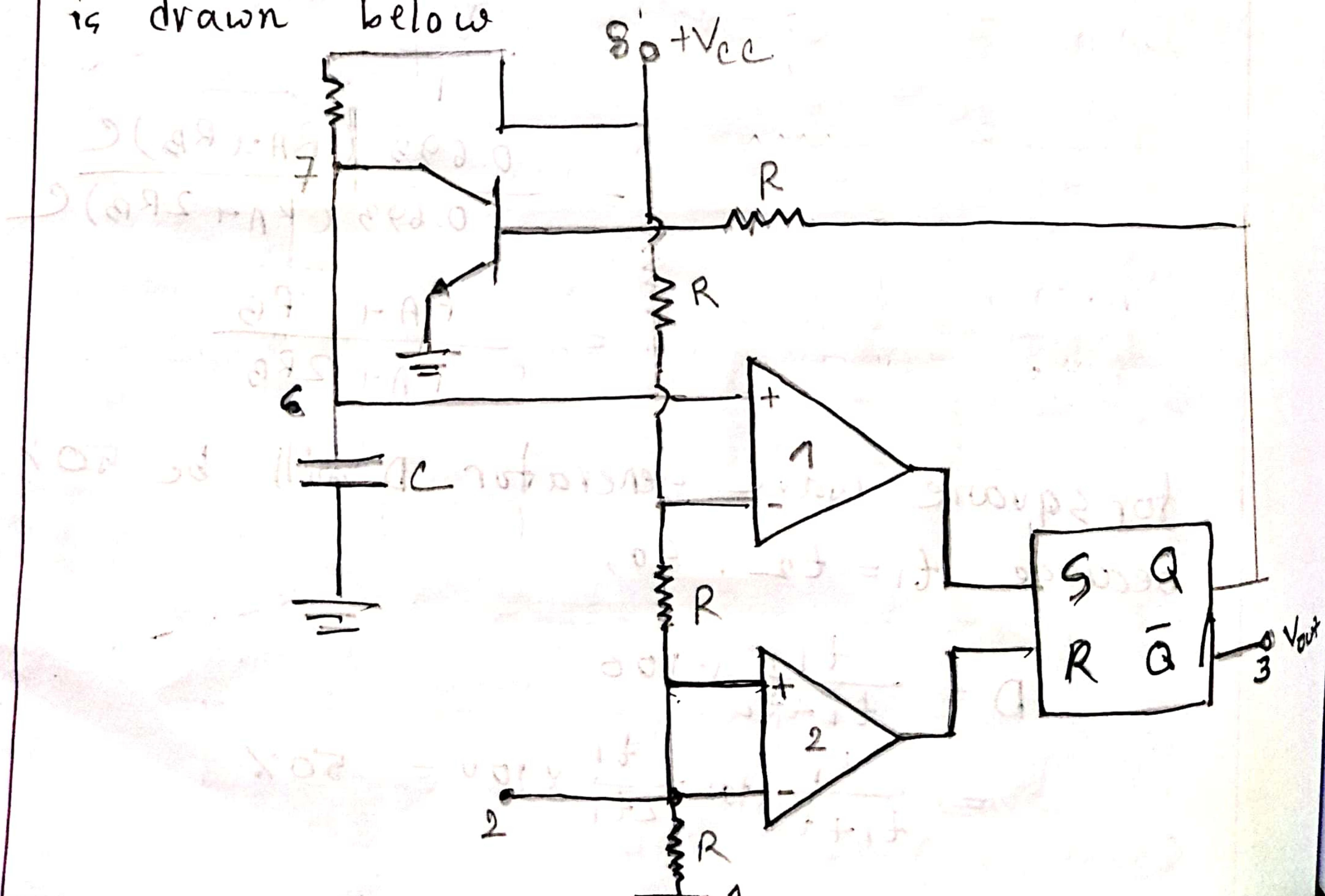
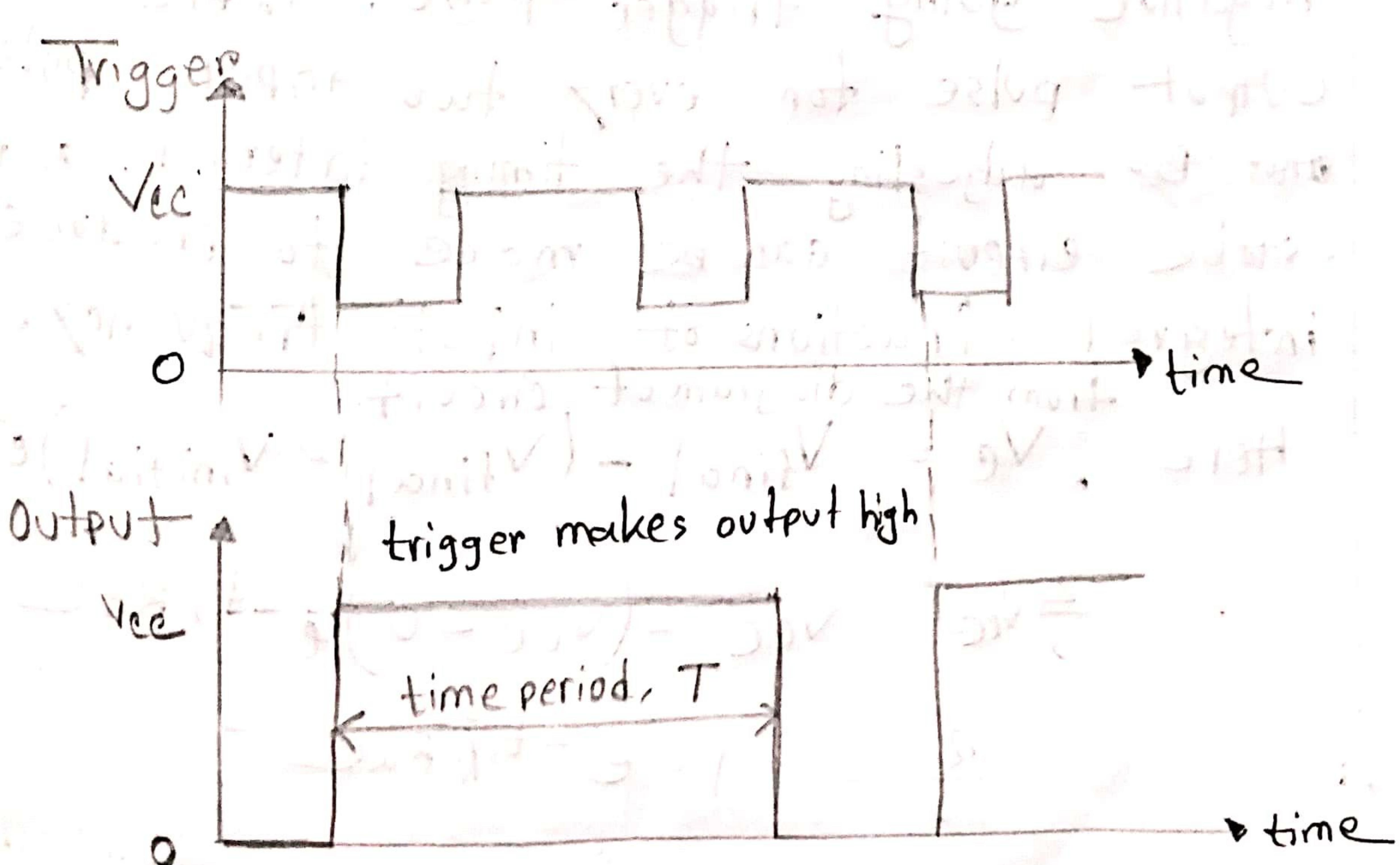


fig: Frequency Divider Circuit

## Working principle:

If the timing interval,  $t$ , is made slightly larger than the time period of the input pulse (trigger pulse), the device can act as a divide by two circuit. The timing interval can be controlled by appropriately choosing the values of the resistor,  $R$  and the capacitor  $C$  in the timing circuit. The waveforms of the input and output signals corresponding to the divide-by-two circuit are shown below.



The circuit will trigger for the first negative pulse of the trigger input. As a result, the

output will go to high state. The output will remain high for the time interval, even if a second negative going trigger pulse is applied, the output will not be affected and continues to remain high as the timing interval is greater than the time period of the trigger pulse. On the third negative going trigger pulse, the circuit is retriggered.

So, the circuit will trigger on every alternate negative going trigger pulse, there is one output pulse for every two input pulses, and by adjusting the timing interval, a mono-stable circuit can be made to produce integral fractions of input frequency.

From the diagram of circuit.

$$\text{Here, } V_C = V_{final} - (V_{final} - V_{initial}) e^{-t/RC}$$

$$\frac{2}{3} V_{CC} = V_{CC} - (V_{CC} - 0) e^{-t/RC}$$

$$\frac{2}{3} = 1 - e^{-t/RC}$$

$$\therefore t_{high} = 1.1 RC$$

where we can denote  $t_{high} = T$