Introduction to ~~T~~ Timer

An electronic timer is a circuit which drives other systems such as alarm, control system, after a specific time period depending on the values of components used. This time period can be varied. The basic idea behind the time is charging & discharging of an external capacitor through switching circuitry.

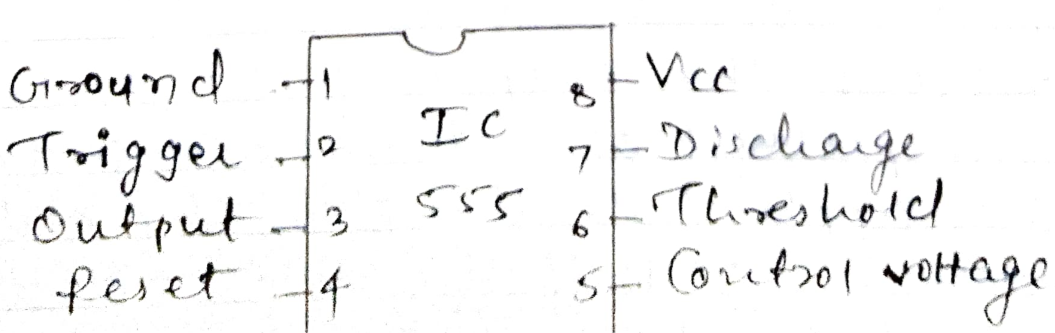
⇒ Applications

Oscillator, pulse generator, ramp or square wave generator, Monostable, Astable, bistable multivibrator.

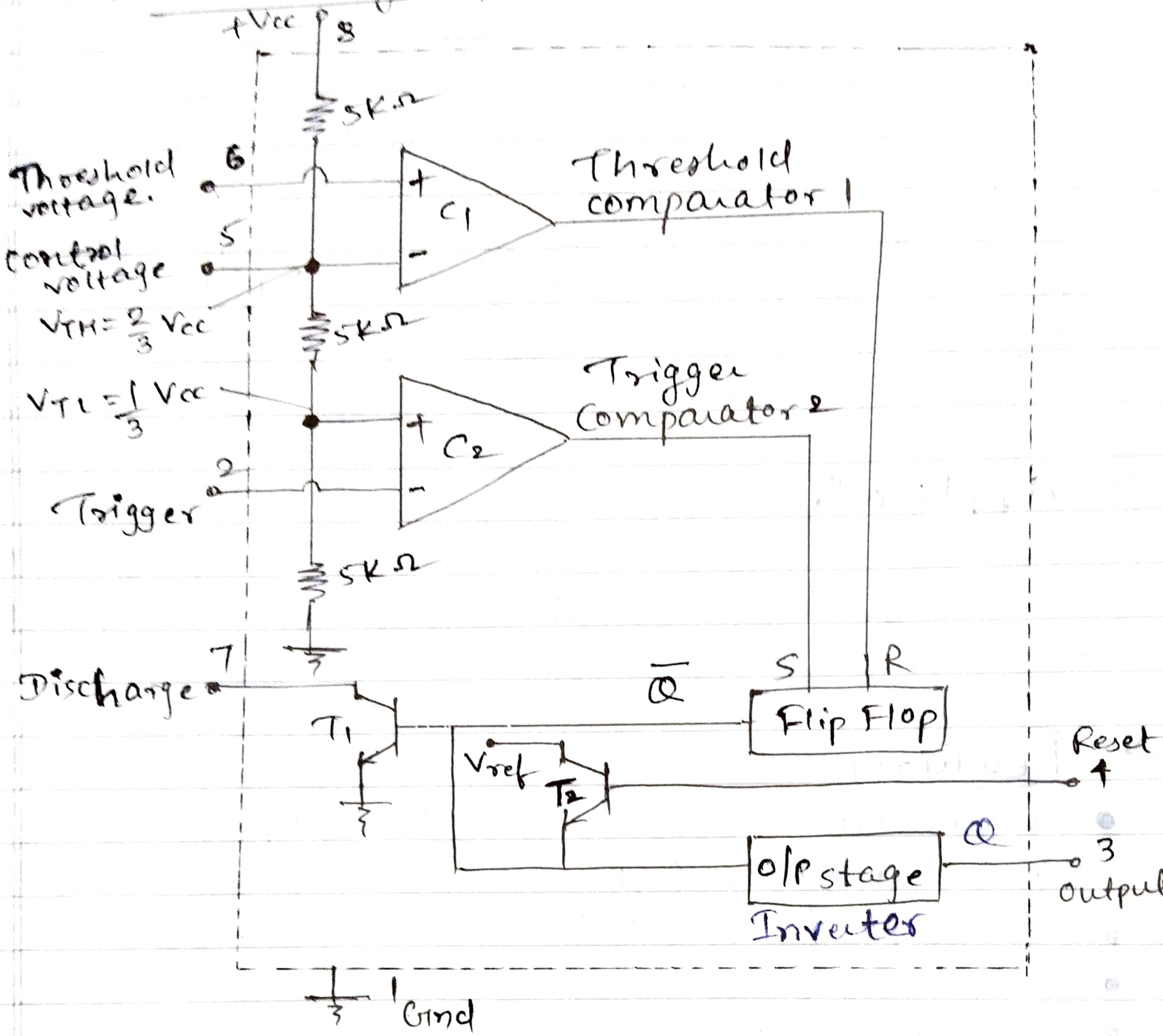
⇒ Features

- Operation on +5V to +18V supply voltage in both astable & monostable modes.
- Timing from microseconds to hours.
- High current output.
- Output can drive TTL family.
- Reliable, easy to use, low cost.

⇒ PIN diagram



★ Block diagram.



→ PIN FUNCTION

→ Ground : All voltages are measured with respect to this terminal.

→ Trigger : The output of the timer depends on amplitude of external ~~voltage~~ trigger pulse applied to this pin. The output of timer is HIGH if the voltage at this pin is less than $\frac{1}{3} V_{cc}$. The output remains High as long as the trigger terminal is held at a low voltage.

Output: This is the output of the Timer & the load is to be connected to this pin. There are two ways a load can be connected to the o/p terminal. Either pin 3 & ground (pin 1) or between pin 3 & supply voltage Vcc (pin 8).
When the output is low, the load current flows through the load connected between pin 3 & +Vcc into the output terminal & is called the sink current.
When the output is high, the current through the load between pin 3 & +Vcc is zero. This current is called source current.

Reset: The 555 timer can be reset by applying a -ve pulse to this pin. When the reset function is not in use, this terminal should be connected to +Vcc to avoid any possibility of false Triggering.

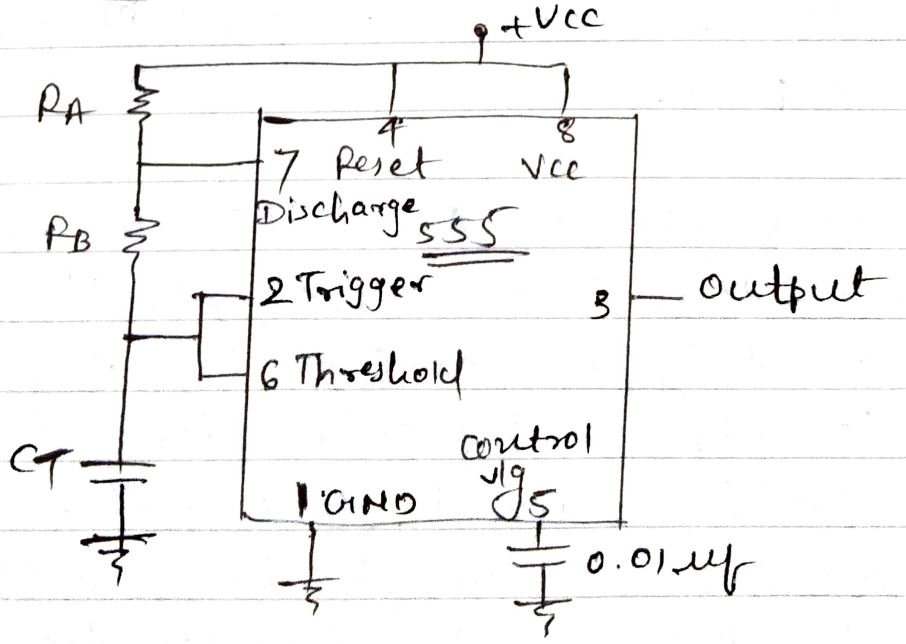
Control voltage: An external voltage applied to this terminal changes the threshold as well as trigger voltage. By imposing a voltage on this pin or by connecting a pot between this pin & ground, the pulse width of output ~~voltage~~ wave form can be varied. When not in use, the control pin should be bypassed to ground with 0.01 uf capacitor to prevent any noise problem.

→ Threshold: when the voltage at this pin is greater than or equal to $\frac{2}{3}$ Vcc, the o/p of comparator 1 goes high, which in turn switches the output of the timer low.

→ Discharge: This pin is connected internally to the collector of transistor T_1, as shown in fig. when output is high, T_1 is off & acts as an open circuit to external capacitor 'C' connected across it. when output is low, T_1 is saturated (ON) & acts as a shorting out the external capacitor C to ground.

→ +Vcc : The supply voltage of +5v to +18v is applied to this pin with respect to ground.

☆ Astable Multivibrator



→ Astable multivibrator is a circuit which will trigger itself & go from one state to another state after a predetermined interval of time. It has two quasi stable states, generating rectangular waveforms.

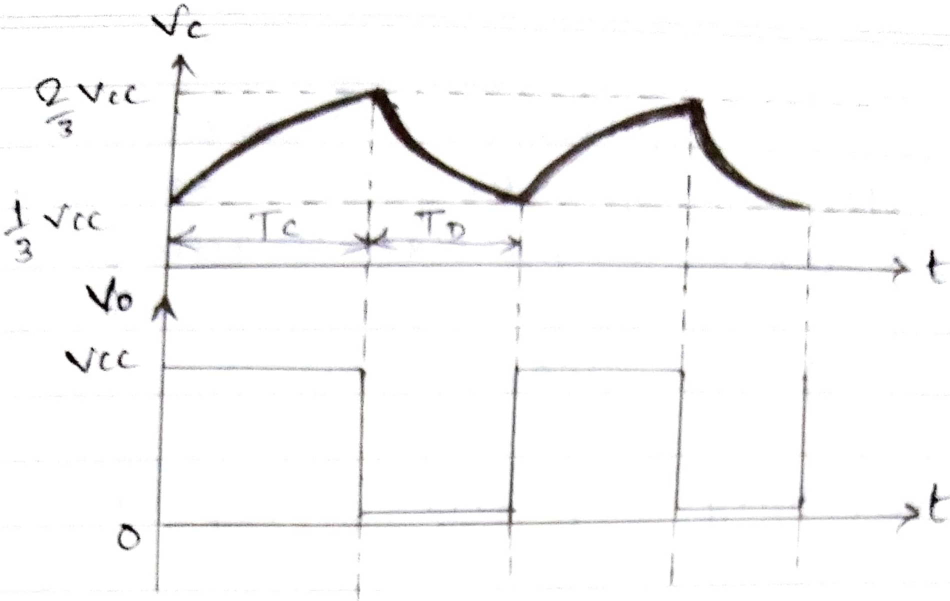
→ Initially capacitor is kept uncharged. When Vcc is applied, the internal transistor is held OFF & the output goes high. The external capacitor C_T charges through R_A & R_B with time constant $(R_A+R_B)C_T$.

→ When the voltage across capacitor reaches $\frac{2}{3}V_{cc}$ it makes a positive transition near the reference voltage of comparator C_1 i.e. o/p of C_1 goes high which resets the flip flop. The output of IC goes low.

→ The internal Transistor T_1 is ON & capacitor discharges through R_B & internal transistor T_1 to ground.

→ When capacitor discharges to $\frac{1}{3}V_{cc}$, it makes output of comparator 'C_2' high, which sets the flip flop. The output goes high. The internal transistor T_1 becomes off & capacitor again starts charging. The discharging time constant is $R_B C_T$.

→ Subsequently capacitor charges from $\frac{1}{3}V_{cc}$ to $\frac{2}{3}V_{cc}$ & discharges from $\frac{2}{3}V_{cc}$ to $\frac{1}{3}V_{cc}$. The cycle repeats & generates rectangular pulses at the output.



$$T_{ON} \text{ ie. } T_C = (R_A + R_B) C_T \ln\left(\frac{V_{CC} - \frac{1}{3}V_{CC}}{V_{CC} - \frac{2}{3}V_{CC}}\right)$$

$$\therefore T_C = (R_A + R_B) C_T \ln\left(\frac{2V_{CC}/3}{V_{CC}/3}\right)$$

$$\boxed{T_C = 0.693\,(R_A + R_B)\,C_T}$$

$$T_{OFF} \text{ ie. } T_D = R_B \cdot C_T \ln\left(\frac{0 - \frac{2}{3}V_{CC}}{0 - \frac{1}{3}V_{CC}}\right) = \boxed{0.693 R_B C_T}$$

Total time $T = T_{ON} + T_{OFF}$

$$T = 0.693(R_A + R_B) C_T + 0.693 R_B C_T$$

$$\text{Duty cycle} = \frac{T_{ON}}{T}$$

$$= \frac{0.693(R_A + R_B) C_T}{0.693(R_A + R_B) C_T + 0.693 R_B C_T}$$

$$= \frac{R_A + R_B}{R_A + 2R_B} \times 100$$

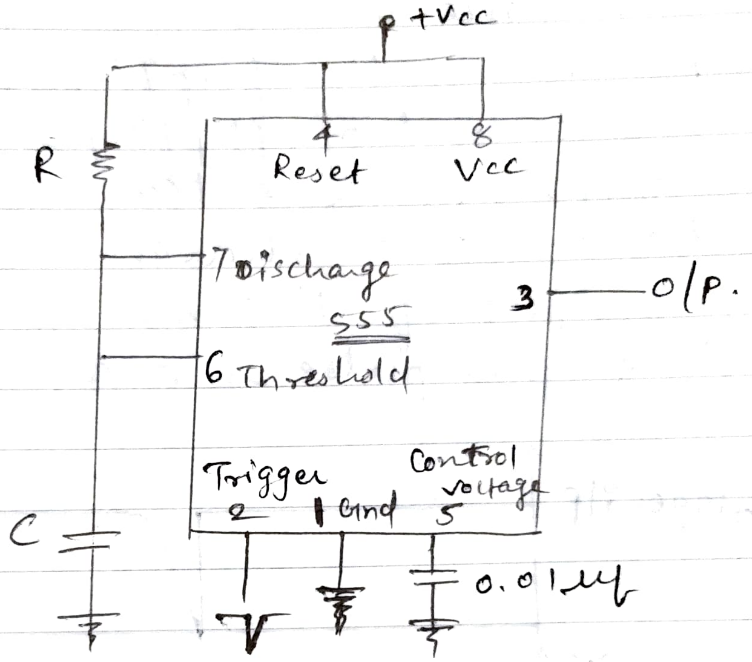
$$\text{Frequency} = \frac{1}{T} = \frac{1}{0.693(R_A + 2R_B) C_T}$$

$$F = \frac{1.45}{(R_A + 2R_B) \cdot C_T} \text{ Hz}$$

→ Application

- → Square wave oscillator
- → Free running ramp generator
- → Voltage control oscillator
- → Schmitt trigger.

★ Monostable Multivibrator



→ Monostable multivibrator is a circuit which is normally in the stable state. On the application of an external Trigger, the output goes to the quasi stable state, remains for predetermined interval of time & comes back to the original stable state.

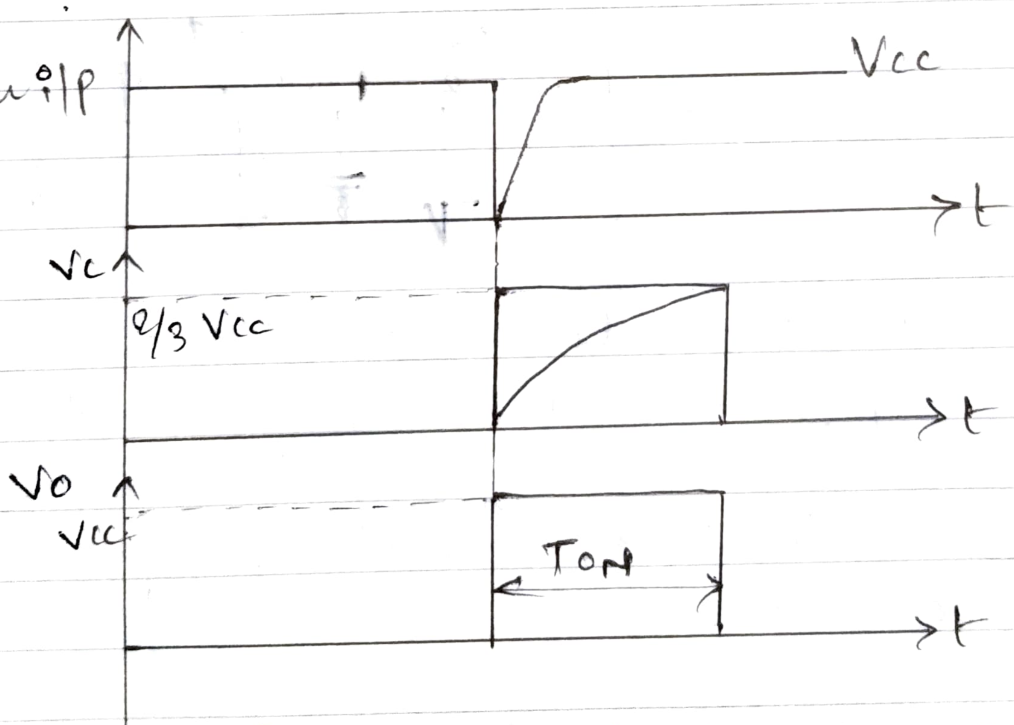
→ Before the application of Trigger pulse, the v/g at trigger input pin 2 is high. The o/p of comparator 'C_2' is low, making the flip flop output $\bar{Q}$ to high & Vo is low. The discharge Transistor T_1 is ON & hence the external capacitor is in discharged state.

→ On the application of -ve going pulse below $\frac{1}{3}V_{cc}$ at pin2, makes output of comparator 'C_2' high which in turn sets the flip flop, $\bar{Q}$ is low & o/p of timer is high.

→ The internal ~~cap~~ transistor T_1 becomes off. The capacitor 'C' charges through R. ~~[illegible]~~

→ when capacitor voltage reaches $\frac{2}{3}V_{cc}$, it crosses the reference voltage of comparator 'C_1' whose output resets the flip flop. Output is low. Then $\bar{Q}$ output of flipflop is high. The transistor T_1 is ON & external capacitor C instantaneously discharges.

→ The output of the monostable remains low until trigger pulse is again applied.



Time duration for which capacitor charges from 0 to $\frac{2}{3}V_{cc}$.

$$\frac{2}{3}V_{cc} = V_{cc}\left[1 - e^{-\frac{T_{ON}}{RC}}\right]$$

$$\cancel{\frac{2}{3}V_{cc}} \cdot e^{-\frac{T_{ON}}{RC}} = 1 - \frac{2}{3} = \frac{1}{3}$$

Taking log on both side.

$$-\frac{T_{ON}}{RC} = \ln \frac{1}{3}$$

$$T_{ON} = RC \ln 3$$

$$\boxed{T_{ON} = 1.1\,RC}$$

Application

- → Frequency divider
- → Missing pulse detector
- → Pulse width modulator
- → Retriggerable monostable M.V.

(1) In an Astable multivibrator ckt, $R_A = 27K\Omega$, $R_B = 39K\Omega$, $C_T = 0.1\mu f$. Calculate frequency of oscillations of o/p. Also calculate T_{ON} & T_{OFF}.

→ $R_A = 27K\Omega$, $R_B = 39K\Omega$, $C_T = 0.1\mu f$.

$T_{ON} = 0.693(R_A + R_B)C_T$.

$= 0.693(27K + 39K)\, 0.1\times10^{-6}$

$= 0.693 \times 66\times10^{3} \times 1\times10^{-7} = \underline{4.57 ms}$

$T_{OFF} = 0.693\, R_B C_T$.

$= 0.693\times39\times10^{3}\times0.1\times10^{-6}$

$= \underline{2.7027 ms}$.

Total time period $T = T_{ON} + T_{OFF}$

$= (4.57 + 2.70) = \underline{7.276 ms}$

Frequency of oscillation $f = \frac{1}{T} = \frac{1}{7.27\times10^{-3}}$

$\therefore f = \frac{10^3}{7.276} = \frac{1000}{7.2765} = 137.43 Hz$

(2) Design an Astable multivibrator using IC555 with a freq. of 2KHz & duty cycle 80%. Draw the designed ckt.

→ $F = 2KHz$, Duty cycle $= 80\%$.

Duty cycle $= \frac{T_{ON}}{T} = \frac{R_A + R_B}{R_A + 2R_B} = 80\% = \frac{8}{10}$

$\frac{R_A + R_B}{R_A + 2R_B} = \frac{4}{5}$

$\therefore 5R_A + 5R_B = 4R_A + 8R_B$

$\therefore R_A = 3R_B$

Frequency of oscillation,

$f = \frac{1.44}{(R_A + 2R_B)C_T}$

Let $C_T = 0.1 \mu f$ //

$$\therefore 2 \times 10^3 = \frac{1.44}{(R_A + 2R_B) \times 0.1 \times 10^{-6}}$$

$$R_A + 2R_B = \frac{1.44}{2 \times 10^3 \times 1 \times 10^{-7}}$$

$$= \frac{1.44}{2 \times 10^{-4}} = \frac{1.44 \times 10 \times 10^3}{2}$$

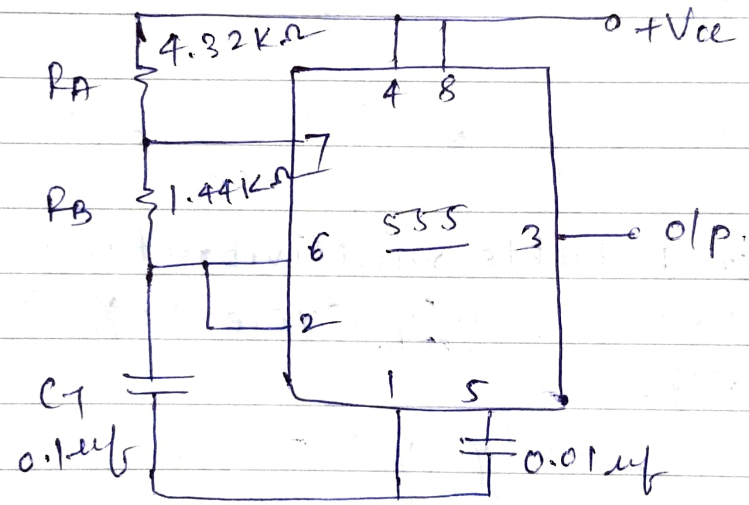
$$= 7.2 K\Omega$$

$\therefore 3R_B + 2R_B = 7.2 K\Omega$ ..... as $R_A = 3R_B$.

$\therefore 5R_B = 7.2 K\Omega$

$\therefore R_B = \frac{7.2}{5} K\Omega = 1.44 K\Omega$ //

& $R_A = 3 \times 1.44 \times 10^3 = 4.32 K\Omega$ //



(3) If $R_Z = 10 K\Omega$, $C_T = 0.05 \mu f$, calculate time period of monostable multivibrator using 555 & Draw the circuit diagram.

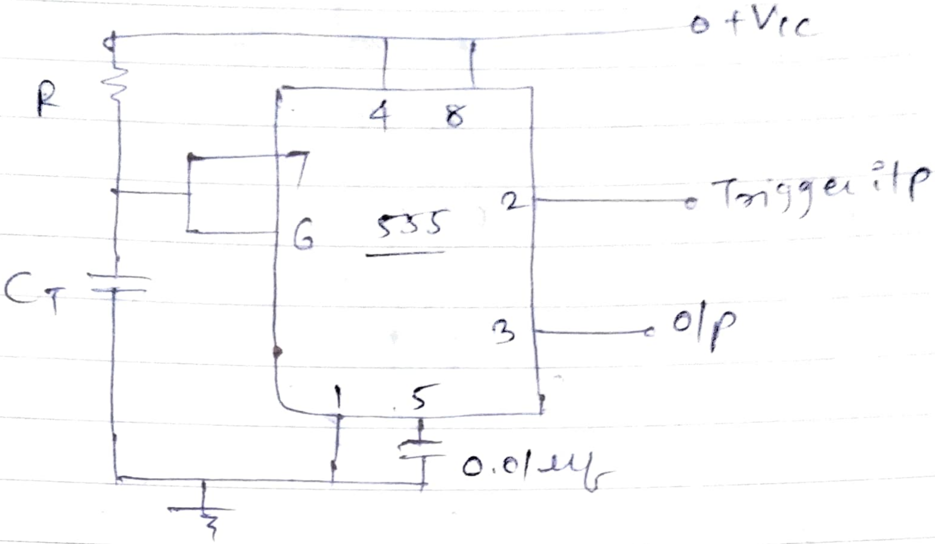
→ $R = 10 K\Omega$, $C_T = 0.05 \mu f$.

Time period $= 1.1 \times R \times C_T$

i.e. pulse width $= 1.1 \times 10 \times 10^3 \times 0.05 \times 10^{-6}$

$= 55 \times 10^{-5} = 55 \times 10^{-2} \times 10^{-3}$ sec.

$T = 0.55$ ms. //



(4) Draw the circuit diagram of astable multivibrator using IC 555 to obtain 50% duty cycle. Determine values of components used at 1KHz frequency when $C_T = 1\mu f$. Draw waveform of astable multivibrator.

→ Duty cycle = 50%, f = 1KHz, $C_T = 1\mu f$.

For duty cycle = 50%

$t_c = t_d$ ie. charging time = Discharging time

$\therefore T_{ON} = T_{OFF}$

$f = 1KHz$

$$T = \frac{1}{f} = \frac{1}{1KHz} = \frac{1}{10^3} = 1\times10^{-3}\text{ sec.}$$

Total time $T = T_{ON} + T_{OFF}$

$= 2T_{ON}$

$$T_{ON} = T_{OFF} = \frac{T}{2} = \frac{1ms}{2} = 0.5\text{ msec}$$

$T_{OFF} = 0.693\, R_B C_T$

$0.5ms = 0.693 \times R_B \times 1 \times 10^{-6}$

$$\therefore R_B = \frac{0.5\times10^{-3}}{0.693\times10^{-6}}$$

$= 0.5/0.693 \times 10^3 = 0.72\times1000$

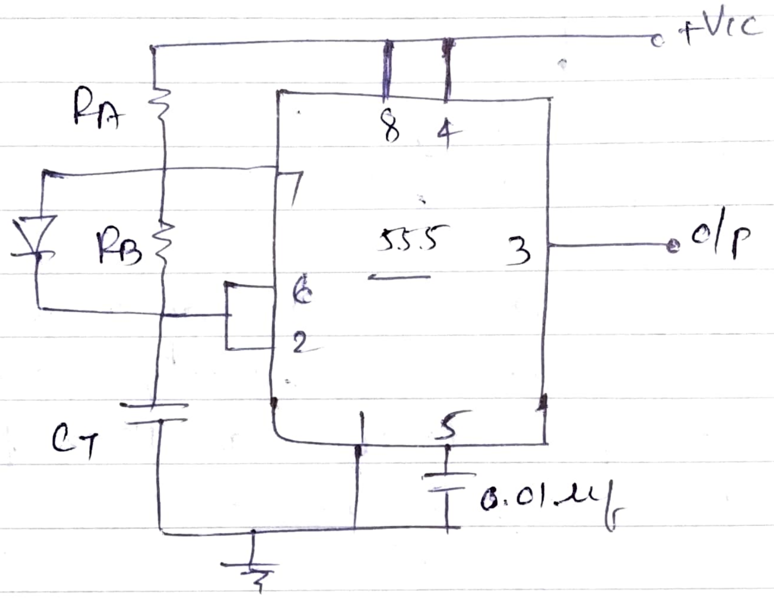
$R_B = 721.5\Omega$

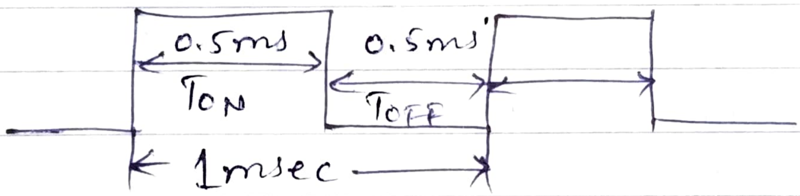
$T_{ON} = 0.693\,(R_A + \cancel{R_B}\ r_f)\, C_T$

$T_{ON} = 0.693\, R_A C_T$ ... neglecting r_f.

As, $T_{ON} = T_{OFF}$

$R_A = R_B = 72\cancel{0}1.5\,\Omega$





(5) Determine pulsewidth of monostable m.v. if $C = 0.047\,\mu f$, $R = 56\,K\Omega$.

→ pulse width $t_p = 1.1 \times R \times C$

$= 1.1 \times 56 \times 10^{3} \times 0.047 \times 10^{-6}$

$t_p = 2.8952 \times 10^{-3}$

$t_p = 2.90$ msec.

(6) If $R_A = 2\,K\Omega$, $R_B = 5\,K\Omega$, $C_T = 2.5\,\mu f$, calculate T_{ON}, T_{OFF}. IC 555 as astable multivibrator. Determine duty cycle of ckt using above component.

→ $R_A = 2k\Omega$, $R_B = 5k\Omega$, $C_T = 2.5\mu f$

$T_{ON} = 0.693\,(R_A + R_B)\,C_T$

$= 0.693\,(2k\Omega + 5k\Omega) \times 2.5 \times 10^{-6}$

$= 0.693 \times 7 \times 10^{3} \times 2.5 \times 10^{-6}$

$T_{ON} = 12.1275\ ms.$

$T_{OFF} = 0.693 \times R_B \times C_T$

$= 0.693 \times 5 \times 10^{3} \times 2.5 \times 10^{-6}$

$= 0.693 \times 5 \times 2.5 \times 10^{-3}$

$T_{OFF} = 8.66\ msec.$

Total time, $T = T_{ON} + T_{OFF}$

$= 12.12 + 8.66$

$T = 20.79\ msec.$

$\%$ Duty cycle $= \dfrac{T_{ON}}{T} \times 100\%$

$= \dfrac{12.1275}{20.79} \times 100\%$

$\%$ Duty cycle. $= 58.33\ \%$

7) In monostable multivibrator using IC 555, $R = 15k\Omega$, o/p pulse width $t_p = 10ms$. Determine value of C. Draw designed ckt.

→ $R = 15k\Omega$, $t_p = 10ms$, $C = ?$

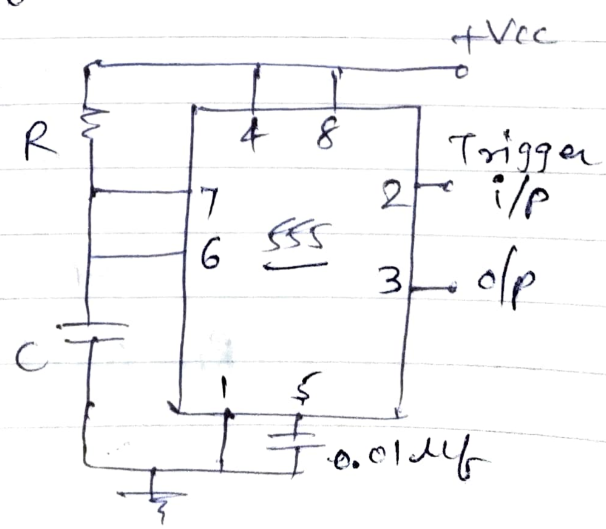
$t_p = 1.1 \times R \times C$

$10ms = 1.1 \times 15 \times 10^{3} \times C$

$\therefore C = \dfrac{10 \times 10^{-3}}{1.1 \times 15 \times 10^{3}} = \dfrac{10}{16.5} \times 10^{-6}$

$\therefore C = 0.606 \times 10^{-6} F$

$\therefore C = 0.6\mu f$



(8) Design an Astable multivibrator using IC555 with free running freq. of 1KHz & duty cycle 70%, Assume $C_T = 0.1\mu f$. Draw designed ckt & wave form.

→ $f = 1KHz$, Duty cycle $= 70\%$, $C_T = 0.1\mu f$

Duty cycle $= \frac{R_A + R_B}{R_A + 2R_B} = 70\% = \frac{70}{100} = \frac{7}{10}$

$\therefore \frac{R_A + R_B}{R_A + 2R_B} = \frac{7}{10}$

$\therefore 7R_A + 14R_B = 10R_A + 10R_B$

$\therefore 4R_B = 3R_A$

$\therefore R_B = \frac{3}{4} R_A \longrightarrow ①$

Free running freq. $f = \frac{1.44}{(R_A + 2R_B)C_T}$

$\therefore R_A + 2R_B = \frac{1.44}{f \times C_T}$

$\therefore R_A + 2R_B = \frac{1.44}{1 \times 10^3 \times 0.1 \times 10^{-6}}$

$\therefore \quad = 1.44 \times 10^4$

$\therefore R_A + 2R_B = 14.4\ K\Omega$.

but from equation ①

$R_A + 2 \times \frac{3}{4} R_A = 14.4\ K\Omega$

$5/2\ R_A = 14.4\ K\Omega$

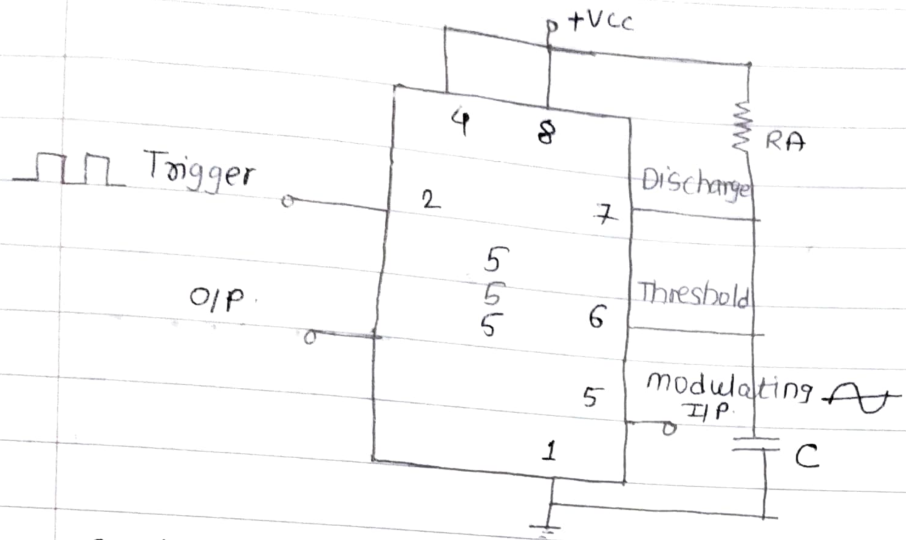
$R_A = \frac{2 \times 14.4}{5}\ K\Omega = 5.76\ K\Omega$

$R_B = \frac{3}{4} \times 5.76\ K\Omega = 4.32\ K\Omega$

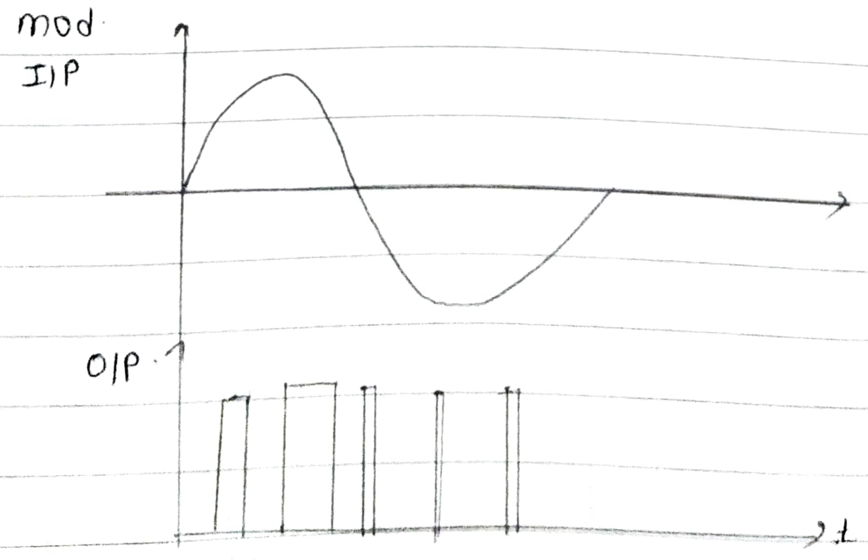
$\therefore R_A = 5.76\ K\Omega$, $R_B = 4.32\ K\Omega$, $C_T = 0.1\mu f$

* Applications of IC 555 :-

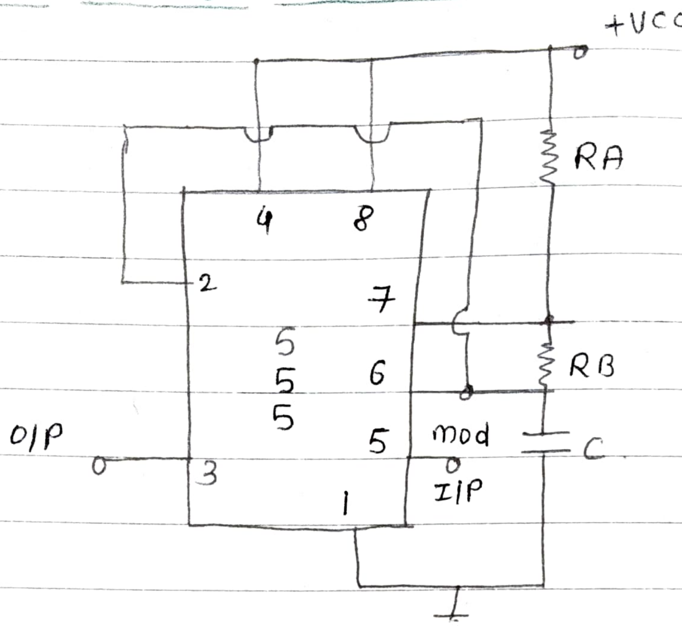
1> Pulse width modulation :-

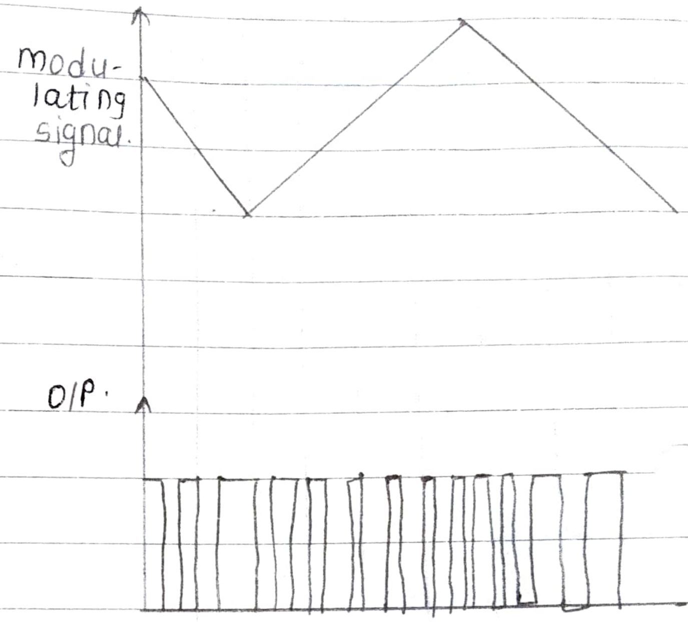


- Basically a mmv with modulating I/P signal applied at pin no 5.
- Continuous trigger is applied at pin no 2. A series of pulses are generated at O/P, the duration of which depends on the modulating input at pin no. 5.
- modulating I/P gets superimposed upon the already existing voltage (2/3) Vcc at inverting I/P terminal of upper comparator. This in turn changes the threshold level of VC & the O/P pulse width modulation takes place.
- O/P freq^n remains same as that of the applied trigger pulse. only the duty cycle will change.



2) Pulse Position modulator :-





- PPM can be constructed by applying modulating signal to pin 5 of 555 connected for astable operation. The O/P pulse position varies with the modulating signal, since the threshold vtg & hence the time delay is varied. Here triangular wave is applied as modulating signal. [RA = 3.9 K, RB = 3 K, C = 0.01 uF.
Vcc = 5V]

3) Schmitt Trigger :-