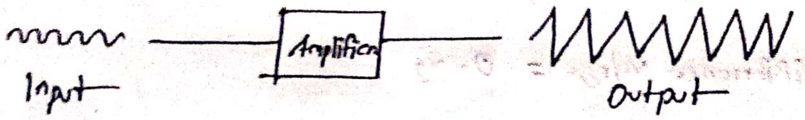
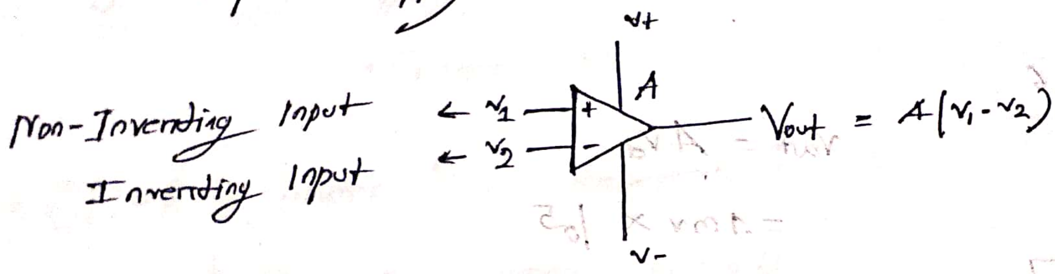
OP-AMP ⟶ Operational Amplifier

Introduction to op-amp



Op-amp

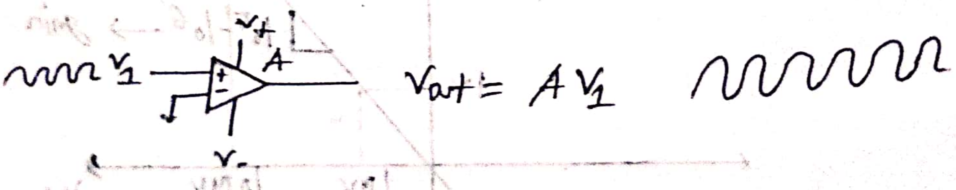
- 2 input & 1 output
- 2 power supply



Let's say, v_1 & v_2 are the input signal & gain of the operational Amplifier A

$$V_{out} = A(v_1 - v_2)$$

#

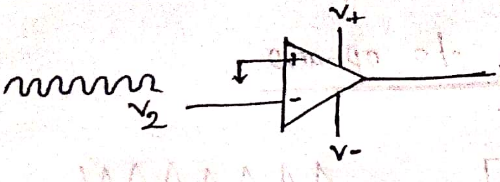


Voltage Difference

$v_1 - 0$

$= v_1$

Inverted terminal



$V_{out} = \boxed{-AV_2}$

Difference voltage $= 0 - v_2$

$= -v_2$

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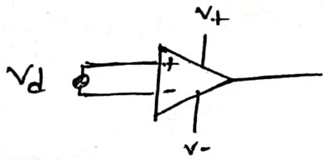


$V_{out} = AV_d$

$A = 10^5 - 10^6$

$v_d = 1mv$

$V_{out} = AV_d$

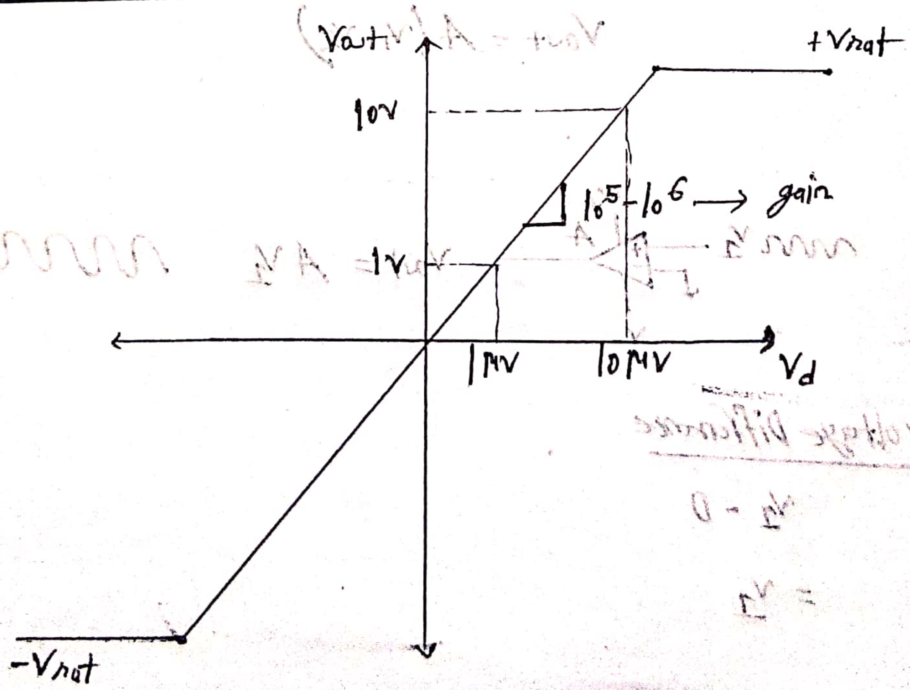
$= 1mv \times 10^5$

$\boxed{1mv = 10^{-3}v}$

$= 1 \times 10^{-3} \times 10^5$

$= 100V$

voltage Transfere Curve of op-amp

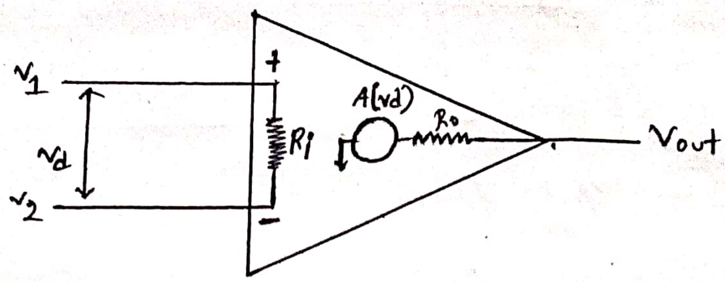


OP-AMP Equivalent Circuit

R_i = Input Impedence

R_o = Output ''

$V_{out} = A(v_d)$



Characteristics of ideal OP-AMP

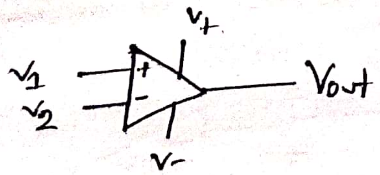
- $R_i = \infty$
- $R_o = 0$
- Bandwidth $= \infty$
- gain $A = \infty$
- Slewrate $= \infty$

- CMRR = Common Mode Rejection Ration

↳ If $v_1 = v_2$ then $V_{out} = 0$

$$= \frac{A_d}{A_c} = \frac{\text{differential gain}}{\text{Common Mode gain}} = \infty$$

Schmitt Trigger Explained

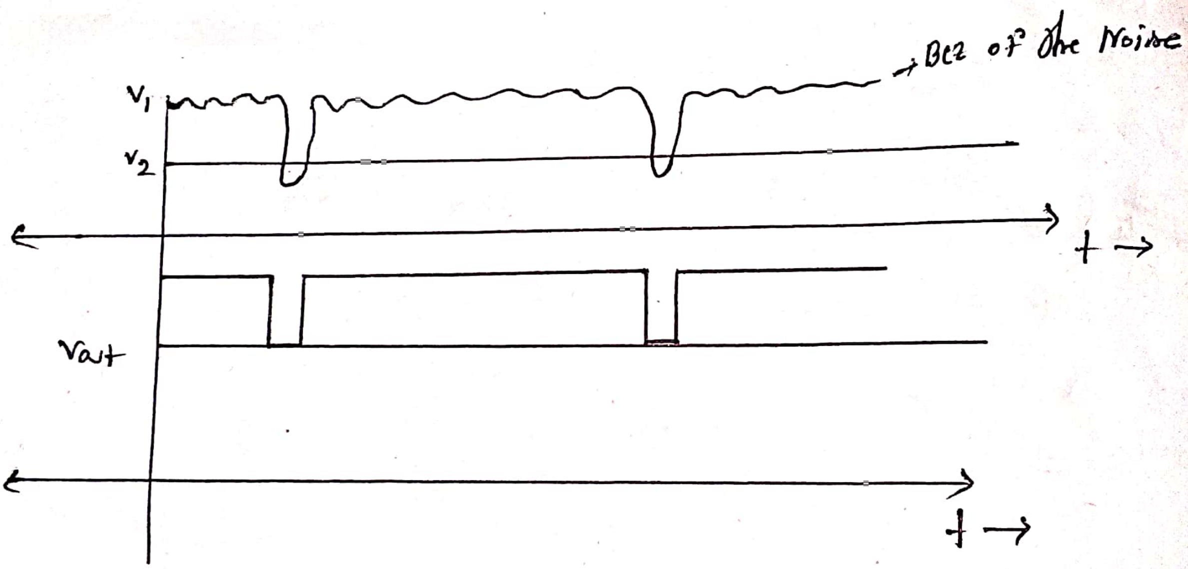


Comparator

⇒ If input signal is Noisy then output will be affected.

⇒ This kind of Noise Problem Can be Avoided by using

[Schmitt Trigger]

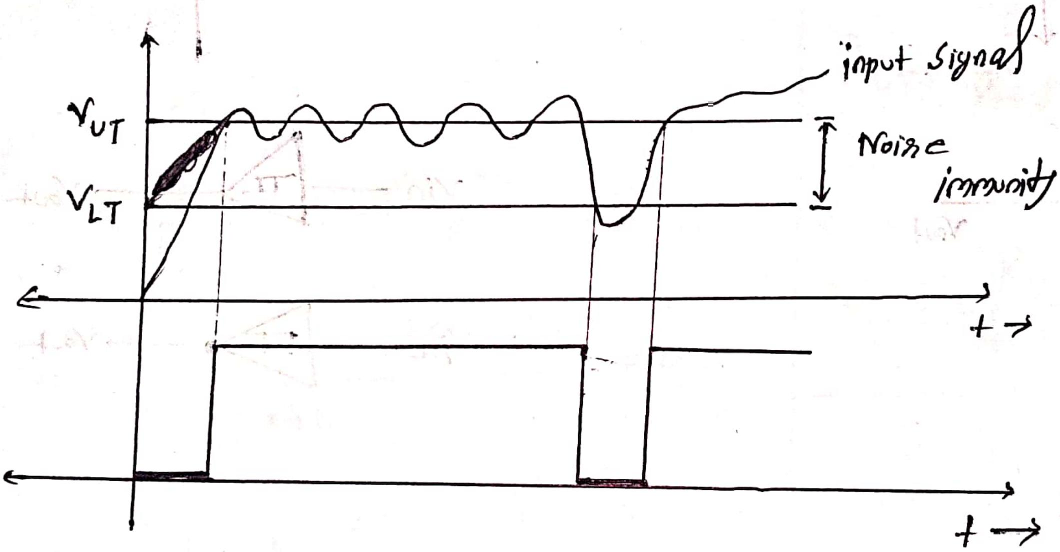


Schmitt Trigger

\# Schmitt Trigger = Comparator with Hysteresis

⇒ It means that, Schmitt Trigger has 2 Threshold Voltage:

1. Upper Threshold Voltage → Low to High
2. Lower " " → High to Low



\# Hysteresis Voltage = $V_{UT} - V_{LT}$

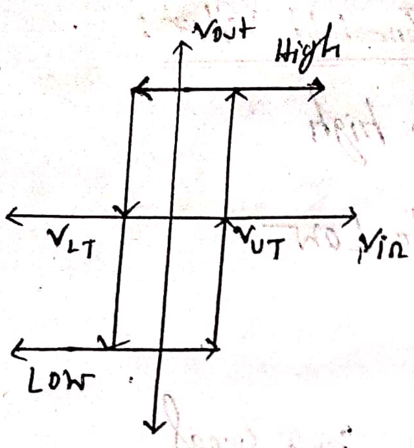
⇒ If input signal less than $\boxed{V_{UT}}$ then output remain $\boxed{\text{LOW}}$

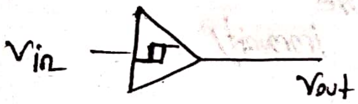
⇒ As soon as it cross the $\boxed{V_{UT}}$ then output will become $\boxed{\text{High}}$

⇒ As soon as input signal goes below $\boxed{V_{LT}}$ then output will become $\boxed{\text{LOW}}$

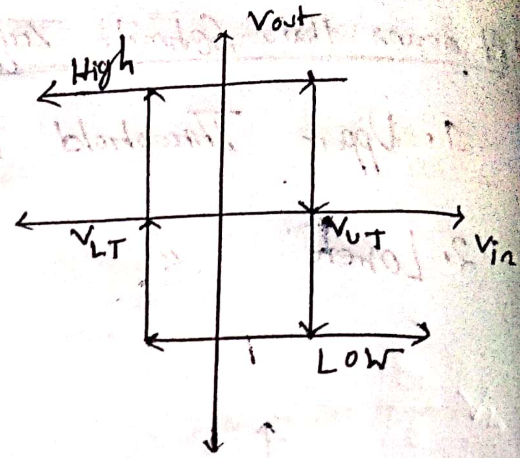
~~Schit~~

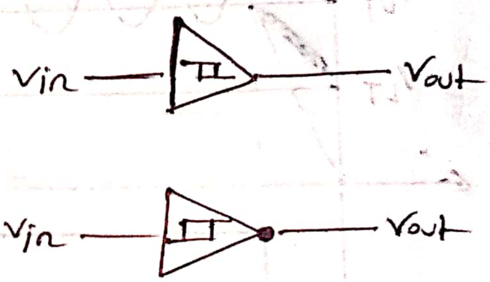
Schmitt Trigger..



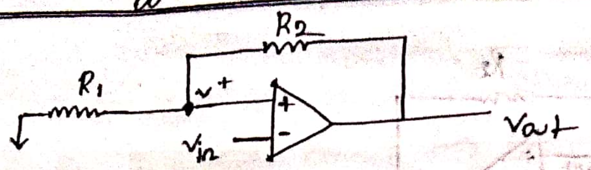


Inverting Schmitt Trigger





Inverting Schmitt trigger with op-amp



When,

$$V_{in} > v^+ \implies V_{out} = V_L$$

$$V_{in} < v^+ \implies V_{out} = V_H$$

Applying KCL,

$$\frac{v^+ - 0}{R_1} + \frac{v^+ - V_{out}}{R_2} = 0$$

$$\Rightarrow \frac{v^+}{R_1} + \frac{v^+ - V_{out}}{R_2} = 0$$

$$\Rightarrow \frac{v^+ R_2 + v^+ R_1 - R_1 V_{out}}{R_1 R_2} = 0$$

$$\Rightarrow v^+ R_2 + v^+ R_1 = R_1 V_{out}$$

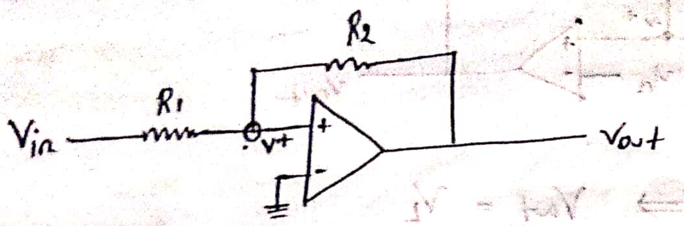
$$\Rightarrow v^+ (R_1 + R_2) = R_1 V_{out}$$

$$\Rightarrow v^+ = \frac{R_1}{R_1 + R_2} V_{out}$$

$$\boxed{V_{UT} = \frac{R_1}{R_1 + R_2} \times V_H}$$

$$\boxed{V_{LT} = \frac{R_1}{R_1 + R_2} \times V_L}$$

Non- Inverting Schmitt Trigger



$V^+ > 0 \Rightarrow V_{out} = V_H$

$V^+ < 0 \Rightarrow V_{out} = V_L$

$V_{UT} = -\frac{R_1}{R_2} \times V_L$

$V_{LT} = -\frac{R_1}{R_2} \times V_H$

Applying KCL,

$$\frac{v^+ - v_{in}}{R_1} + \frac{v^+ - v_{out}}{R_2} = 0$$

$$\Rightarrow v^+\left[\frac{1}{R_1} + \frac{1}{R_2}\right] = \frac{v_{in}}{R_1} + \frac{v_{out}}{R_2}$$

$$\Rightarrow v^+\left[\frac{R_2 + R_1}{R_1 R_2}\right] = \frac{v_{in}}{R_1} + \frac{v_{out}}{R_2}$$

$$\Rightarrow v^+ = \frac{R_2}{R_1 + R_2} v_{in} + \frac{R_1}{R_1 + R_2} v_{out}$$

$$\Rightarrow v^+ = \frac{R_2}{R_1 + R_2} v_{in} + \frac{R_1}{R_1 + R_2} V_L$$

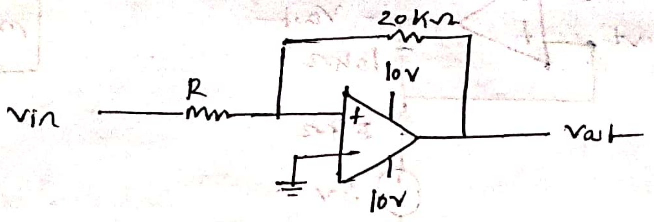
$v_1 > v_0 \Rightarrow v_{out} = V_H$

$$* \quad \frac{R_2}{R_1 + R_2} v_{in} > -V_L \cdot \frac{R_1}{R_1 + R_2} \quad \Rightarrow V_{in} > -\frac{R_1}{R_2} \times v_2$$

Duty Cycle $= \dfrac{\text{ON time Pulse}}{\text{Total time}} = \dfrac{T_{on}}{T}$

Example-2

⇒ Find the value of R_1 such that circuit has 1v of Hysteresis width



Soln

this is Non-inverting Schmitt trigger

Here $R_2 = 20k\Omega$, $V_H = 10V$ $V_L = -10V$

$$V_{UT} = -\frac{R_1}{R_2} V_L$$

$$= -\frac{R_1}{R_2} \times -10V$$

$$= 10\frac{R_1}{R_2}$$

$$V_{LT} = -\frac{R_1}{R_2} V_H$$

$$= -\frac{R_1}{R_2} \times 10V$$

$$= -10\frac{R_1}{R_2}$$

Hysteresis width $= V_{UT} - V_{LT}$

$$= 10\frac{R_1}{R_2} + 10\frac{R_1}{R_2}$$

$$= 20\frac{R_1}{R_2}$$

Given that, $20\dfrac{R_1}{R_2} = 1v$

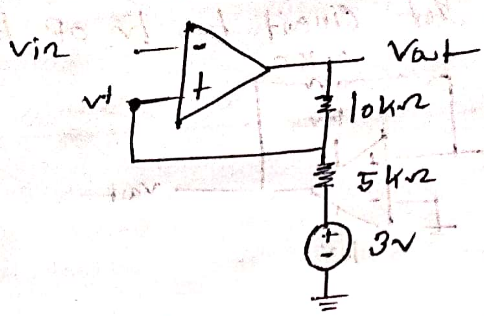
$$\Rightarrow R_1 = \frac{1 \times R_2}{20} = \frac{1 \times 20k\Omega}{20} = 1k\Omega$$

$$\boxed{\text{So, } R_1 = 1k\Omega}$$

Example-3

For the given op-amp Saturation voltage are $\pm 15V$.

Find Upper and Lower threshold voltage.



Saturation means Vout

Soln:

This is ~~non~~ inverting Schmitt trigger.

Suppose:

$V_{out} = +15V$

Applying KCL,

$$\frac{v^+ - 3V}{5} + \frac{v^+ - 15V}{10} = 0$$

$$\Rightarrow 2v^+ - 6V + v^+ - 15V = 0$$

$$\Rightarrow 3v^+ = 21V$$

$$\Rightarrow v^+ = 7V$$

$$\therefore V_{UT} = 7V$$

Again, suppose, $V_{out} = -15V$

Applying KCL,
$$\frac{V^+ - 3V}{5} + \frac{V^+ + 15V}{10} = 0$$

$$\Rightarrow 2V^+ - 6V + V^+ + 15V = 0$$

$$\Rightarrow 3V^+ = -9V$$

$$\Rightarrow V^+ = -3V$$

$$\therefore V_{LT} = -3V$$

Ans; $V_{UT} = 7V$

$V_{LT} = -3V$

$$\text{Hysteresis} = V_{UT} - V_{LT}$$
$$= 7V - (-3V)$$
$$= 7V + 3V$$
$$= 10V$$

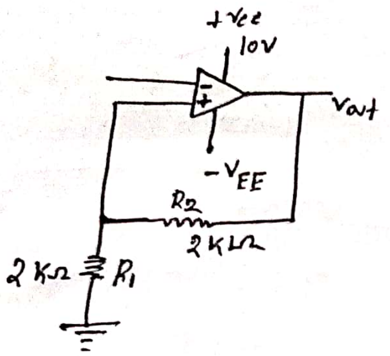
$V_{out} = \beta V_{sat}$

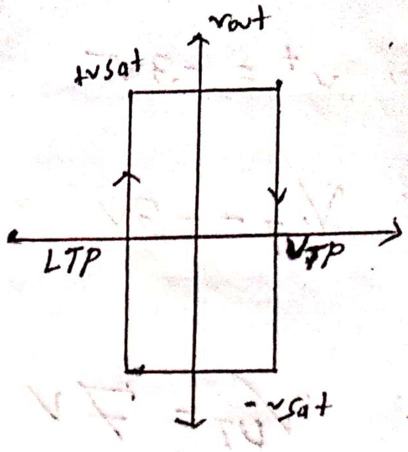
Non-Linear Application of Op-amp

1. By Using Op-amp draw and Explain a Schmitt trigger circuit that has zero volt Centered Hysteresis.

Ans:

Fig shows the Schmitt trigger





Here,

$V_{CC} = 10V$, $R_1 = R_2 = 2 k\Omega$

$V_{cen} = 0V$

Feedback Fraction is, $\beta = \frac{R_1}{R_1 + R_2} = \frac{2}{2+2} = \frac{1}{2}$

The Schmitt trigger has zero volt Centered hysteresis.

The trip point are,

Assume that V_{sat} is 8V

$UTP = V_{cen} + \beta V_{sat}$

$= 0V + \frac{1}{2} \times 8$

$= 4V$

$LTP = V_{cen} - \beta V_{sat}$

$= 0 - \frac{1}{2} \times 8$

$= -4V$

For the positive saturated output, Non-inverting input is equal to the UTP

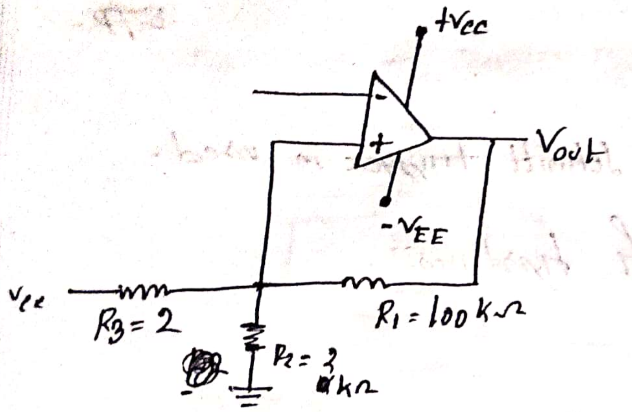
& " " negative " " " " " " to the LTP

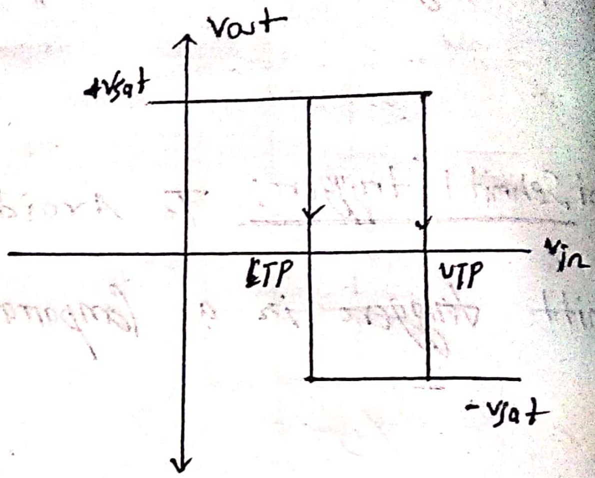
~~Semi~~ Schmitt trigger: To Avoid Noise Schmitt trigger is used.

Schmitt trigger is a Comparator with hysteresis.

③ By Using Op-Amp draw & explain a Schmitt trigger Circuit that has +5V Centered hysteresis:

Ans: Fig shown a Schmitt trigger Circuit





An Additional resistor R_3 is Connected between the non-inverting input & +Vcc. The Centre of the hysteresis loop is,

$$V_{cen} = \frac{R_2}{R_2 + R_3} V_{cc}$$

$$\Rightarrow 5 = \frac{2}{2+2} V_{cc}$$

$$\Rightarrow V_{cc} = 10V$$

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The feedback fraction is $\beta = \frac{R_2 \| R_3}{R_1 + R_2 \| R_3} = \frac{2 \| 2}{100 + 2 \| 2} = \frac{1}{100+1}$

$$= \frac{1}{101}$$

$$\cong 0.01$$

<u>The trip point are,</u>

$UTP = V_{cen} + \beta V_{sat} = 5 + 0.01 \times 10 = 5.1V$

$LTP = V_{cen} - \beta V_{sat} = 5 - 0.01 \times 10 = 4.9V$

<u>Hysteresis</u>: In a Schmitt trigger, the difference between ~~the~~ two trip point is called hysteresis.

3. By Using OP Amp draw and explain a Schmitt trigger circuit to produce ~~Rectangle~~ rectangular wave from Sine wave.

Ans:

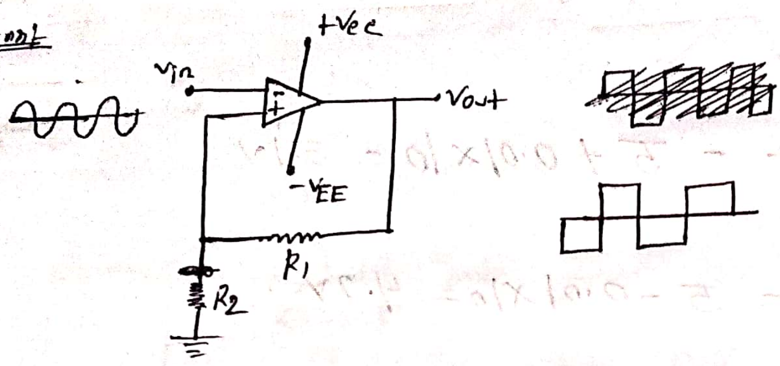


Fig: a

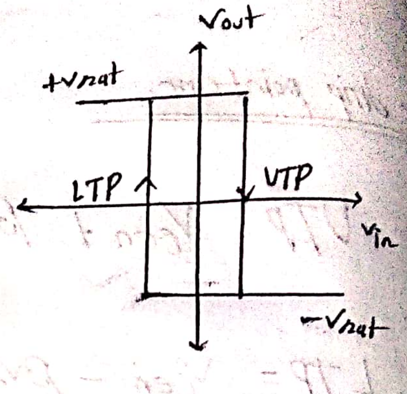


Fig: b

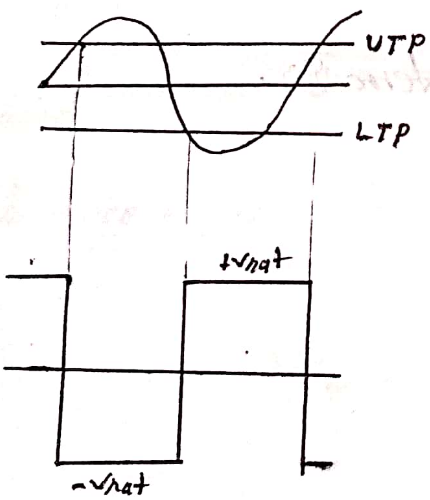


Fig: c

Here,

fig: a = Schmitt trigger

fig: b = Transfer characteristics

fig: c = Output voltage vrs input voltage

⇒ When the input signal is periodic, the output of Schmitt trigger produces a rectangular waveform.

→ ~~If input~~

→ If the input signal less than UTP the output remain High

→ As Soon As input Signal cross UTP then output will become LOW and it remain low untill it ~~cross~~ cross LTP.

→ As soon As input signal cross LTP then output will become High and it remain High untill it cross UTP.

4. By using Op-amp draw and explain a Schmitt trigger circuit to produce triangular wave from rectangular wave.

Ans:

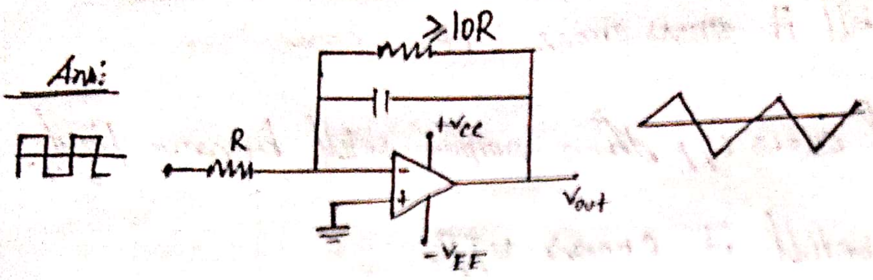


Fig: a

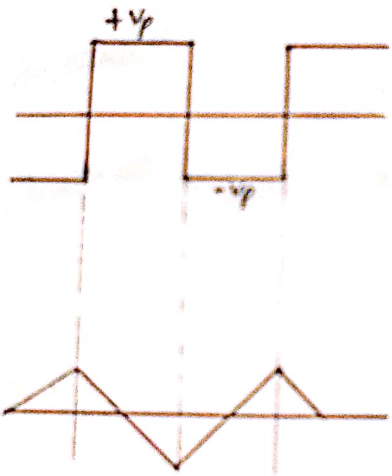


Fig: b

Fig: a → Rectangular input to integrator produces triangular input.

Fig: b → Input output waveform.

Fig(a) Rectangular wave to an integrator. Since the input signal has a dc or average value of zero. The dc & average value of the output is also zero.

Fig(b). The Triangular wave is decreasing when the rectangular wave is increasing.

→ The triangular wave is increasing when the rectangular wave is decreasing.

Oscillator: It's an electric circuit that produces a periodic oscillating electronic signal, often a sine or square wave.

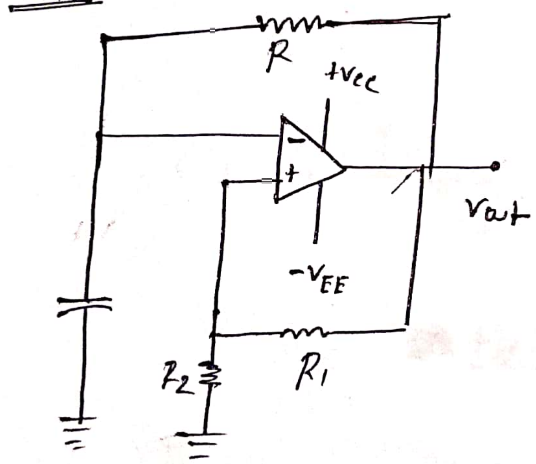
→ Convert DC to AC

⇒ **2 types of Oscillator:**

- Harmonic ⟶ Sinusoidal Output
- Relaxation ⟶ Non-Sinusoidal Output

6. By Using Op-amp Draw and Explain a Relaxation Oscillator:

Ans:



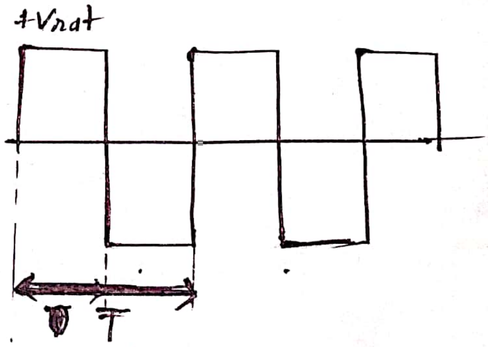
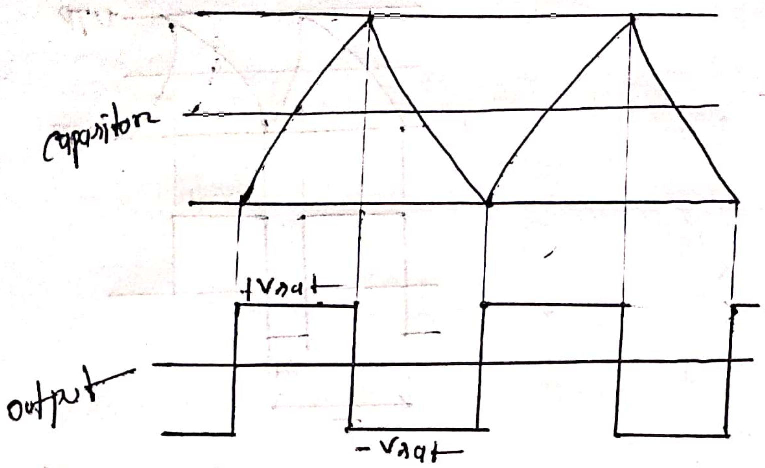


Fig a: Relaxation Oscillator

Figure a shows a relaxation Oscillator that has no input signal but generates an output rectangular wave.

Output signal frequency depends on the charging and discharging of a capacitor or inductor.

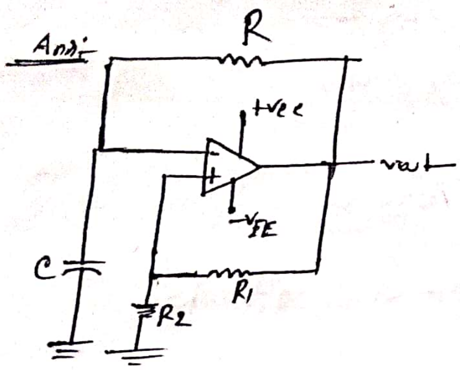


When the output is +Vsat, then the capacitor started charging towards +Vsat. It never reaches +Vsat.

When the output switches to -Vsat then the capacitor started discharging towards -Vsat. It also never reaches -Vsat.

7. Prove that, $T = 2RC \ln \frac{1+\beta}{1-\beta}$ is the period of the output rectangular wave of an op-amp relaxation oscillator, where β = feedback fraction.

Ans:



Fig(a): Relaxation Oscillator

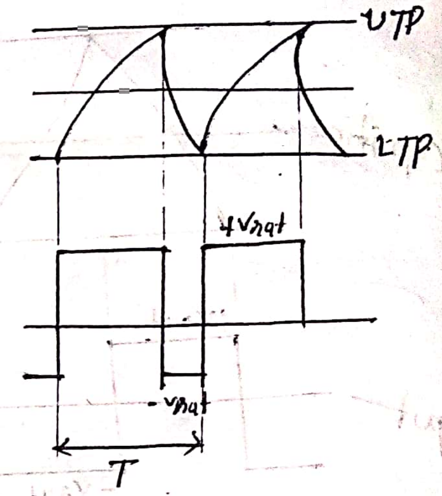


Fig b: Capacitor & output voltage

Figure shows that UTP has a value of $+\beta V_{sat}$ &

LTP " " " " $-\beta V_{sat}$.

We get,

$$V = V_i + (V_f - V_i)\left(1 - e^{-t/RC}\right) \longrightarrow (i)$$

where,

V = Capacitor voltage $\qquad$ t = charging time

V_i = Initial capacitor voltage

V_f = Target " "

the capasitor change start with an initial value $-\beta V_{sat}$ & ends with a value $+\beta V_{sat}$

So here,

$$v_i = -\beta V_{sat}$$

$$V = \beta V_{sat}$$

$$v_f = +V_{sat}$$

$$t = \frac{T}{2}$$

So from eqn (i) ⇒

$$V = v_i + (v_f - v_i)\left(1 - e^{-t/RC}\right)$$

$$\Rightarrow \beta V_{sat} = -\beta V_{sat} + (V_{sat} + \beta V_{sat})\left(1 - e^{-T/2/RC}\right)$$

$$\Rightarrow 2\beta V_{sat} = V_{sat}(1+\beta)\left(1 - e^{-T/2RC}\right)$$

$$\Rightarrow 2\beta = (1+\beta)\left(1 - e^{-T/2RC}\right)$$

$$\Rightarrow \frac{2\beta}{1+\beta} = 1 - e^{-T/2RC}$$

$$\Rightarrow e^{-T/2RC} = 1 - \frac{2\beta}{1+\beta}$$

$$\Rightarrow e^{-T/2RC} = \frac{1+\beta-2\beta}{1+\beta} = \frac{1-\beta}{1+\beta}$$

$$\Rightarrow -T/2RC = \ln\left(\frac{1-\beta}{1+\beta}\right)$$

P.T.O

$\Rightarrow -T = 2RC \ln\left(\frac{1-B}{1+B}\right)$

$\Rightarrow -T = 2RC \cdot -\ln\left(\frac{1+B}{1-B}\right)$

$\therefore T = 2RC \ln\left(\frac{1+B}{1-B}\right)$ $\boxed{\text{Proved}}$

⑧ An op-amp relaxation oscillator has feedback fraction $\beta = 0.9$, feedback resistor $R = 4.7$ ohms & charging-discharging capacitor $C = 0.022\,\mu F$. What is the frequency of the output rectangular wave?

Ans: Given that, $R = 4.7$ $\beta = 0.9$

$C = 0.022\,\mu F$

$f = ?$

$T = 2RC \ln \frac{1+\beta}{1-\beta}$

$= 2 \times 4.7 \times 0.022 \times \ln\left(\frac{1+0.9}{1-0.9}\right)$

$= 0.6089\,s$

$\therefore$ Frequency $f = \frac{1}{T}$

$= \frac{1}{0.6089}$

$= 1.6423\,Hz$

Ans

7. Draw and Explain a practical op-amp integrator. Explain the necessity of large resistor across the capacitor.

Ans:

An integrator produce an output voltage that is proportional to the waveform of the input.

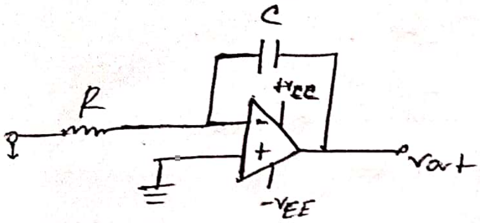
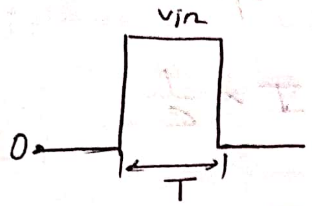
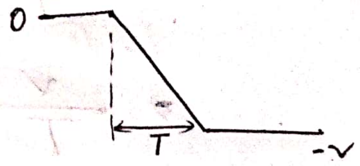


Fig: a Integrator



ⓑ typically input is rectangular wave



ⓒ Typical output

Because of virtual ground, the input ~~cu~~ current is Constant & equals.

$$I_{in} \cong \frac{V_{in}}{R}$$

Approximatly all current goes to the capacitor.

$$C = \frac{Q}{V}$$

$$\therefore V = \frac{Q}{C} \longrightarrow (i)$$

Since Constant current is ~~following~~ flowing into the capacitor change Q increasing linearly.

P. T. O

By dividing the equation (1) by T,

$$\frac{V}{T} = \frac{Q/C}{T}$$

$$\Rightarrow \frac{V}{T} = \frac{Q}{C} \times \frac{1}{T}$$

$$\Rightarrow \frac{V}{T} = \frac{Q}{T} \times \frac{1}{C}$$

$$\Rightarrow \frac{V}{T} = I \times \frac{1}{C}$$

$$\Rightarrow V = \frac{IT}{C}$$

where,

V = Capacitor voltage

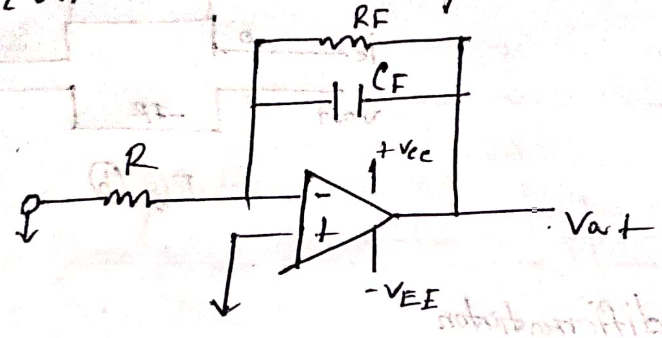
I = Charging Current

T = Charging Time

C = Capacitor

Necessity of large resistor Across the capacitor:

⇒ To Avoid the saturation of the output voltage and to provide gain control, a resistor with large value of resistance can be added in parallel with the capacitor.



(10) Draw and Explain a practical op amp differentiator. Explain the necessity of a small resistor in series with the capacitor.

Ans:-

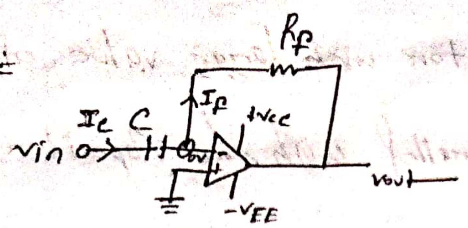


Fig: (a)

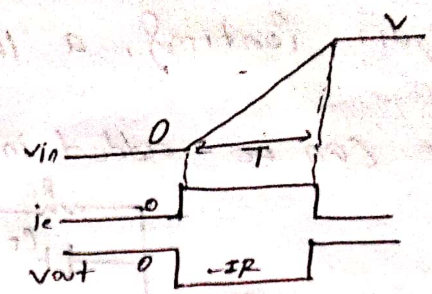


Fig: (b)

Fig(a) shows an op-amp differentiator

Current Ic flowing through this capacitor and

current If " " " Rf and producing

a voltage. This voltage is proportional to the slope of the input voltage.

The op-amp is an ideal op-amp. that's why no current flow inside this op amp.

the capacitor voltage is.

$$V = \frac{Q}{C}$$

Dividing both sides by time T:

$$\Rightarrow \frac{V}{T} = \frac{Q/T}{C}$$

$$\Rightarrow V = \frac{IT}{C}$$

$$\Rightarrow I = \frac{CV}{T}$$

where,

I = Capacitor current

C = Capacitance

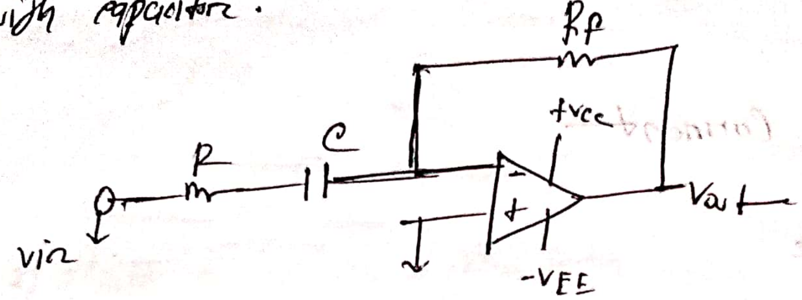
V = voltage at end of op-amp

T = time between start and end of op-amp.

The necessity of small resistor in series with capacitor:

⇒ As the frequency will ~~increase~~ increase, the input impedence of the circuit will reduce.

⇒ To solve this problem a small resistor in series with capacitor.



Multivibrator

#Multivibrator

⇒ The Multivibrator is the electronic Circuit which is used to implement two state devices like Oscillator, Timer and Flip-Flop.

⇒ Two state refers two voltage level

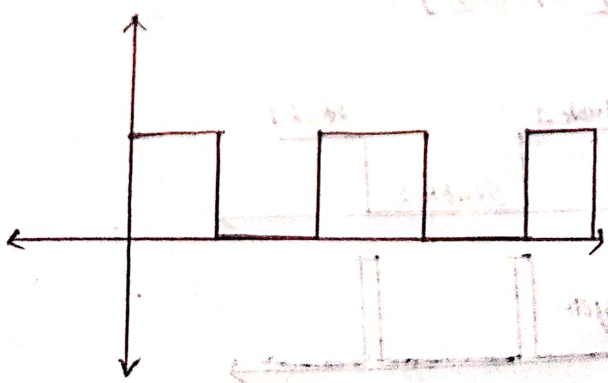
High & low

#3 types

- Monostable Multivibrator → One stable state / One unstable state
- Astable Multivibrator → both are unstable state
- Bistable Multivibrator → Both are stable state

Astable Multivibrator:

- Both are unstable state
- Used in Relaxation Oscillator

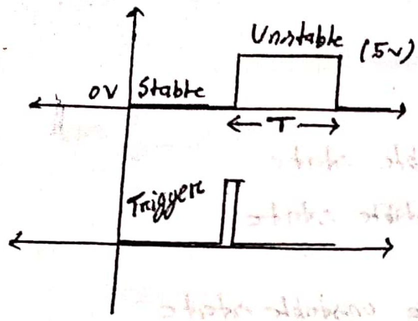


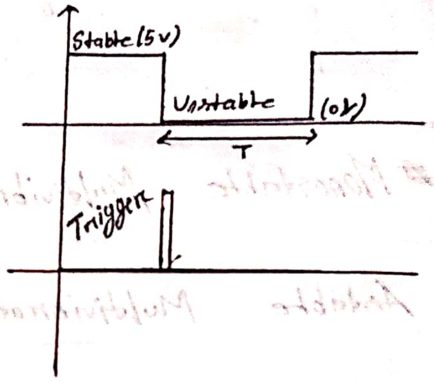
Monostable Multivibrator

- One stable state
- One unstable state

, output remain in the stable state.

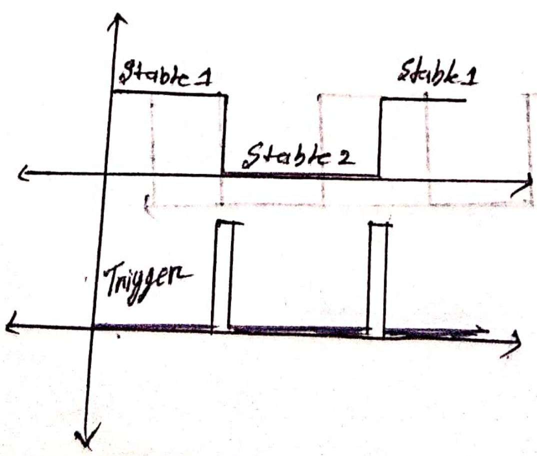
- When external trigger applied output goes to unstable state.
- widely used in [Timer]





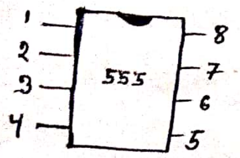
Bistable Multivibrator:

- Both state are stable ~~stab~~ state
- Whenever trigger Applied output goes to one stable to another stable state.
- widely used in [Flip-Flop]



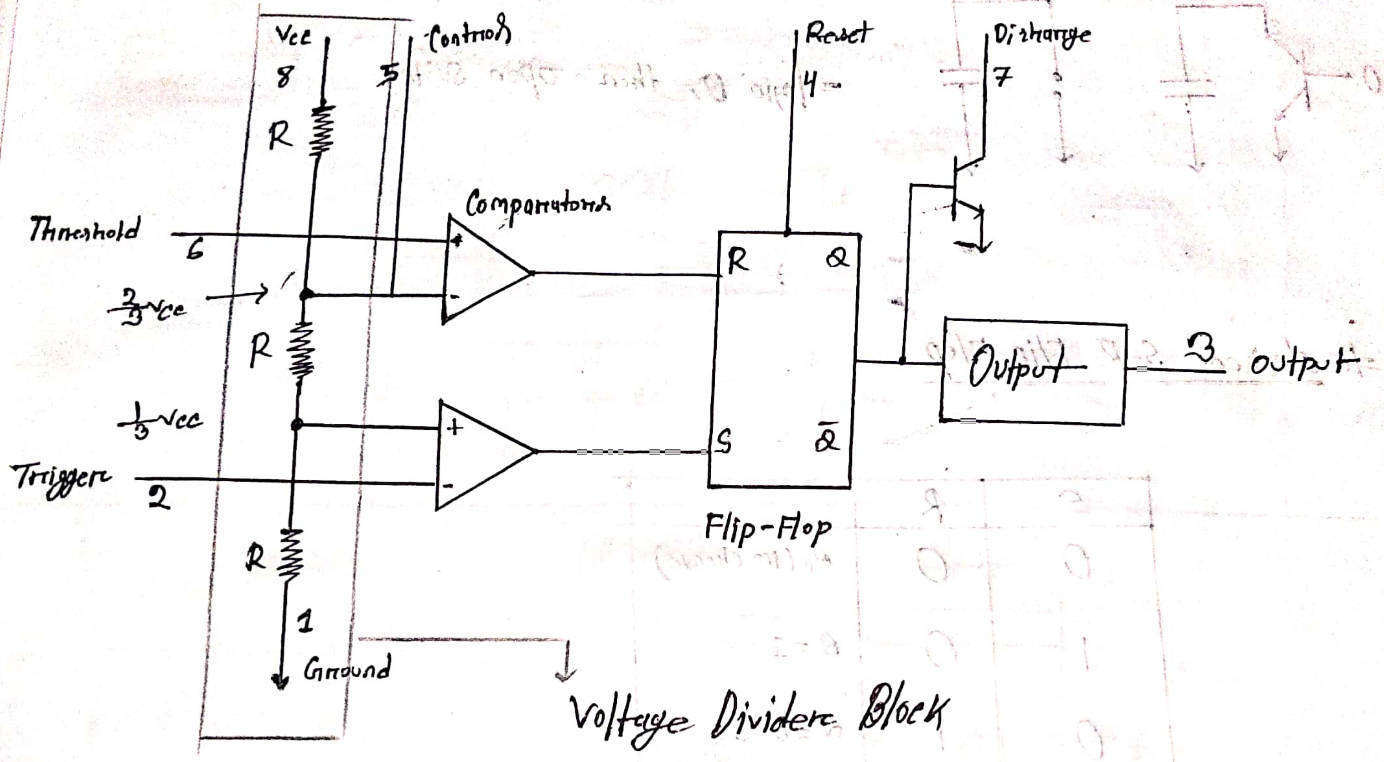
Introduction to 555 timer

GTOR
CTDV



1 → Ground
2 → Trigger
3 → Output
4 → Reset

8 → Vcc
7 → Discharge
6 → Threshold
5 → Control

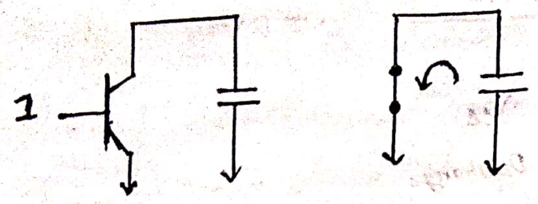


Voltage Divider Block

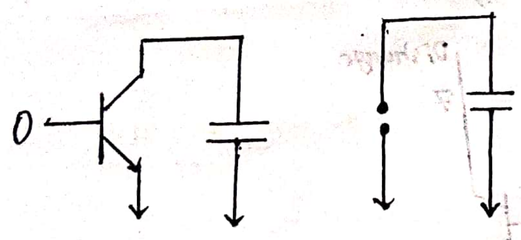
Pin 8 → Supply Voltage Pin 4.5V to 15V.

$\frac{2}{3}$Vcc → High Voltage

$\frac{1}{3}$Vcc → Low Voltage



⇒ logic 1, then close switch



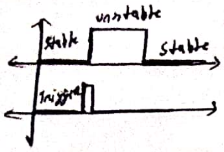
⇒ logic 0, then open switch

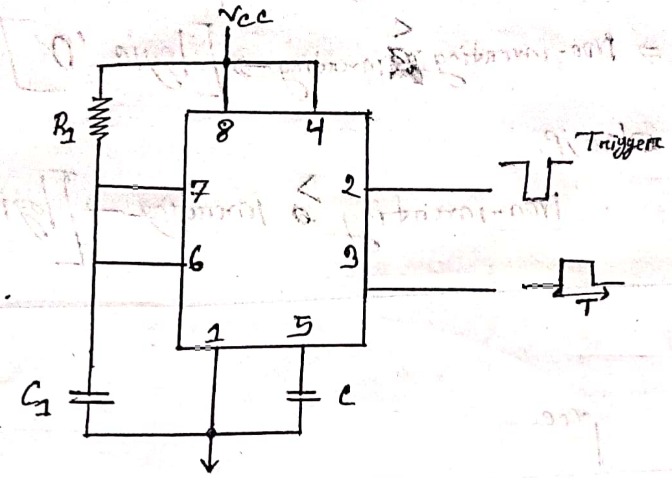
Clocked S-R Flip Flop

S	R	
0	0	Q_0 (No change)
1	0	$Q = 1$
0	1	$Q = 0$
1	1	Invalid

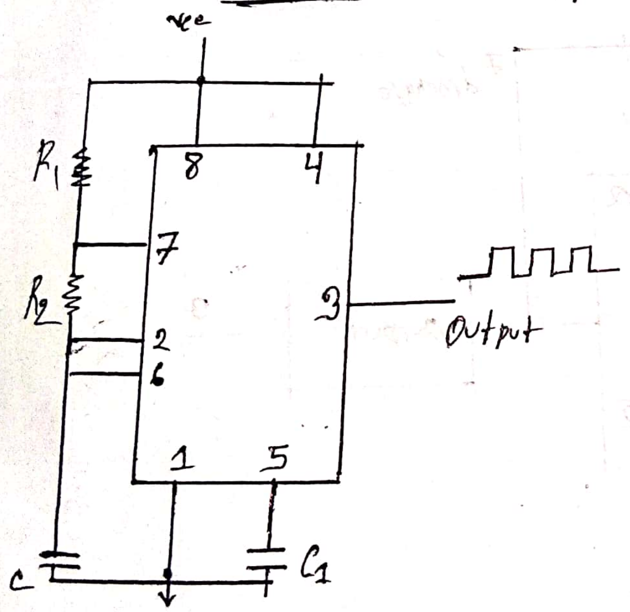
555 timer as Monostable Multivibrator

- One stable state
- One unstable state
- whenever a trigger signal is applied then the stable state goes into unstable state.



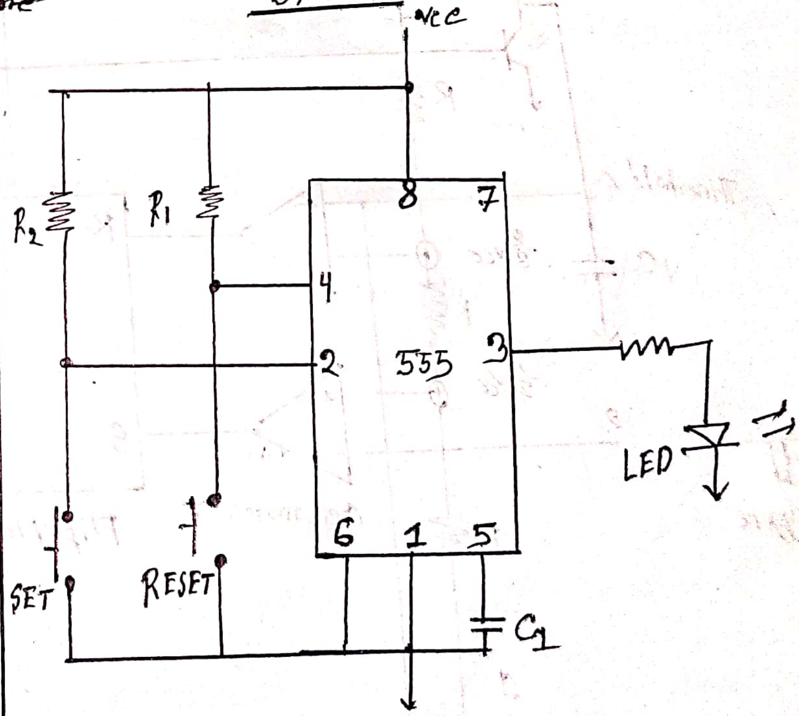


Astable



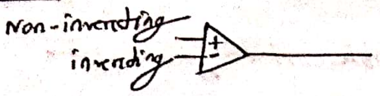
~~Astable~~

Bistable



555 Timer as Monostable Multivibrator

Note:



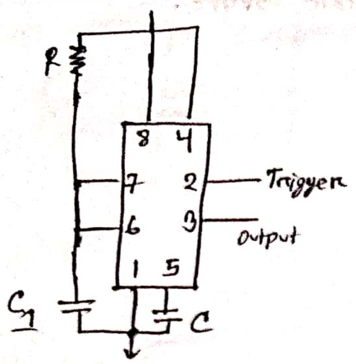
Condition

• If, inverting Node voltage more than Non-inverting Node voltage, then comparator output will be

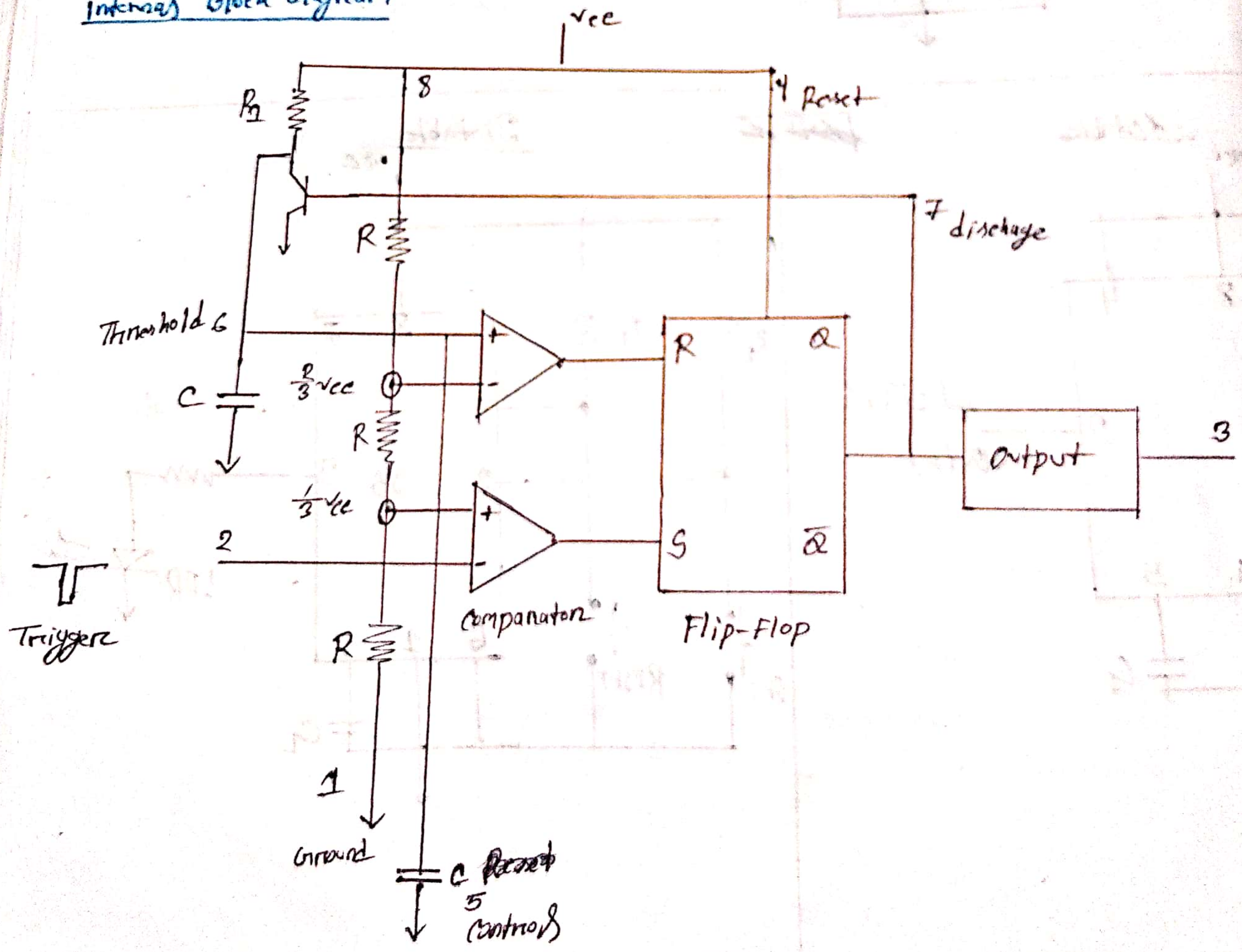
⇒ Non-inverting < inverting → [logic '0']

else if,

Non-inverting > inverting → [logic '1']



internal Block diagram



Working Procedure

⇒ when the output = 0, the $Q = 0$, & $\bar{Q} = 1$

As, $\bar{Q} = 1$, then the transistor ON

⇒ when the pin 6 is ground potential, then voltage at pin 6 $< \frac{2}{3} V_{cc}$

So, the 1st comparator output logic '0'

At the 2nd comparator,

trigger is not applied, then pin 2 at vcc voltage.

then voltage at pin 2 $> \frac{1}{3} V_{cc}$

So, the 2nd comparator output logic '0'

Here,

$$S = 0 \quad R = 0, \quad Q = 0 \;\&\; \bar{Q} = 1$$

⇒ Whenever the trigger is applied, then voltage at pin 2 $< \frac{1}{3} V_{cc}$

So, the 2nd comparator output logic '1'

During triggering action $\bar{Q} = 1$, so this pin 6 remain at ground potential,

So, the output of 1st comparator remain same.

Here,

$$S = 1, \quad R = 0, \quad Q = 1 \;\&\; \bar{Q} = 0$$

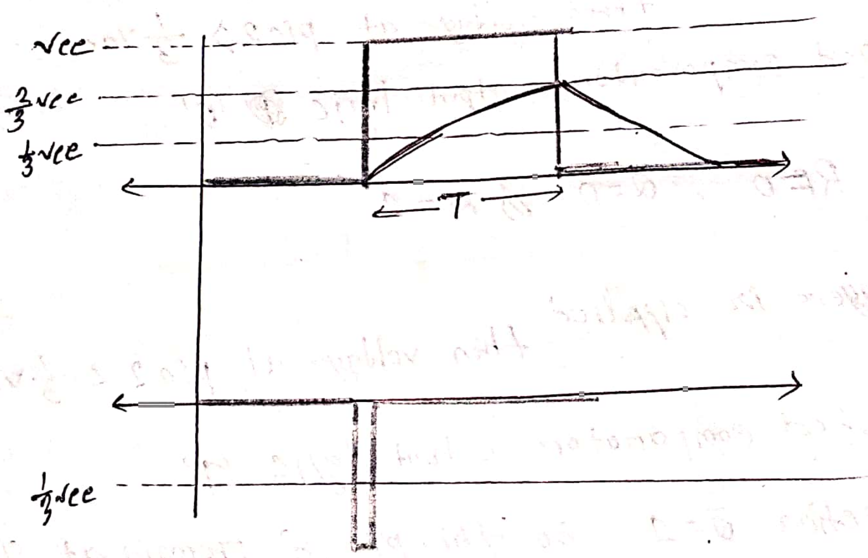
As soon as $\bar{Q} = 0$ the transistor switch off.

And now capacitor C_1 start charging through Vcc.

⇒ After the triggering Action, once again output of the 2nd comparator will logic '0'

Now, during charging capacitor, the voltage at pin 6, just cross $\frac{2}{3}Vcc$ voltage, the output of 1st comparator logic '1'

$R = 1, \quad S = 0 \qquad Q = 0, \quad \bar{Q} = 1$



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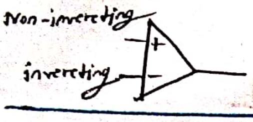
555 timer An Astable Multivibrator

Note



Condition

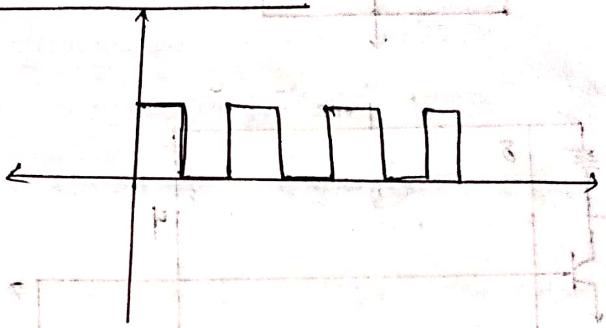
if

Non-inverting voltage < inverting voltage [logic '0']

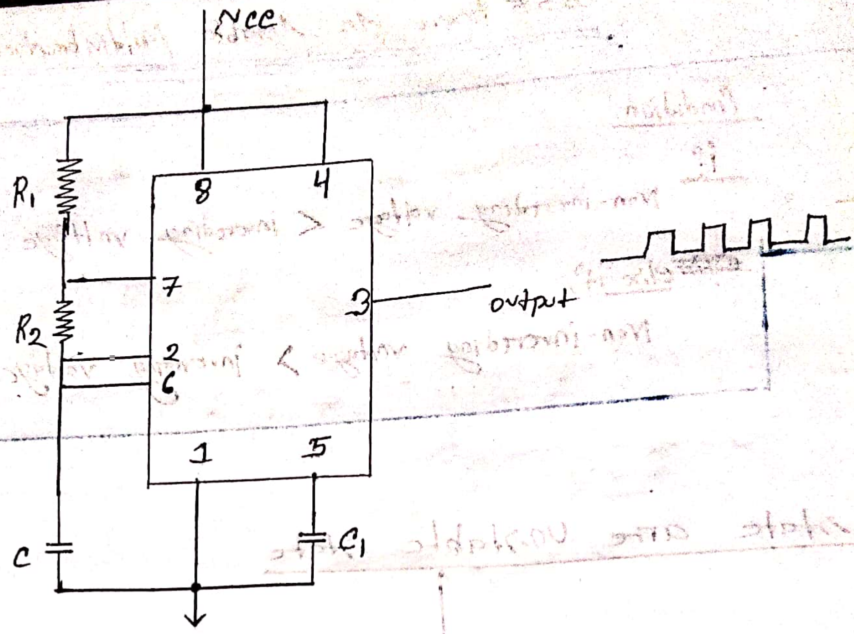
~~[redacted]~~ else if,

Non-inverting voltage > inverting voltage [logic '1']

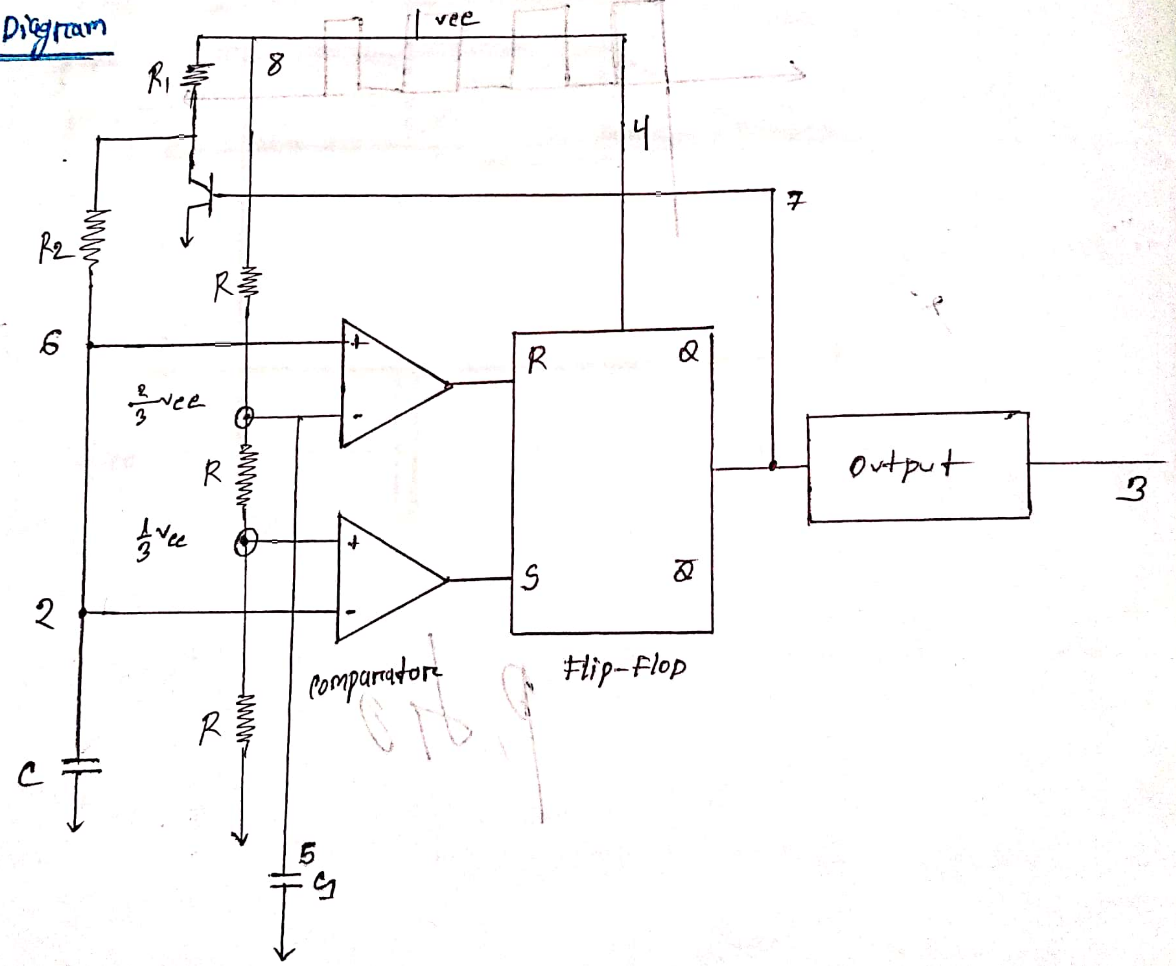
• Both state are unstable state



P, 410



Block Diagram



⇒ ~~Initially~~ For 1st comparator, initially the voltage at the inverting node more than voltage at non-inverting Node.

So, 1st comparator output logic '0'

For 2nd comparator, initially the voltage at the inverting node less than voltage at non-inverting Node.

So, 2nd comparator output logic '1'

Here, $S=1$, $R=0$, $Q=1$ and $\bar{Q}=0$

As soon as $\bar{Q}=0$, the transistor switch off.
So, the capacitor C start charging through R_1 and R_2 gradually.
And the voltage pin 2 and 6 start increasing.

⇒ Whenever, pin 2 voltage cross $\frac{1}{3}$ Vcc voltage, the output of the 2nd comparator logic '0'

Because at that time the voltage at the inverting Node more than the voltage at Non-inverting Node.

While, output of the 1st comparator remain same logic '0'

Here, $S=0$, $R=0$, $Q=1$ and $\bar{Q}=0$.

So, when $S=0$, $R=0$ then, Q will remain same Note

⇒ Whenever, pin 6 voltage Cross $\frac{2}{3}$ Vcc Voltage, the output of the 1st Comparator logic '1'

Because at that time the voltage at the inverting Node ~~or~~ less than the voltage at Non-inverting Node.

While, output of the 2nd comparator remain same logic '0'

Here,

$S=0$, ~~R~~ $R=1$. $Q=0$ & $\bar{Q}=1$

As soon as $\bar{Q}=1$, then the transistor ON

the capacitor C start discharge through the transistor.

⇒ When the voltage at pin 6 < $\frac{2}{3}$Vcc, then the output of the 1st comparator logic '0'

2nd comparator output remain same logic '0'

Here,

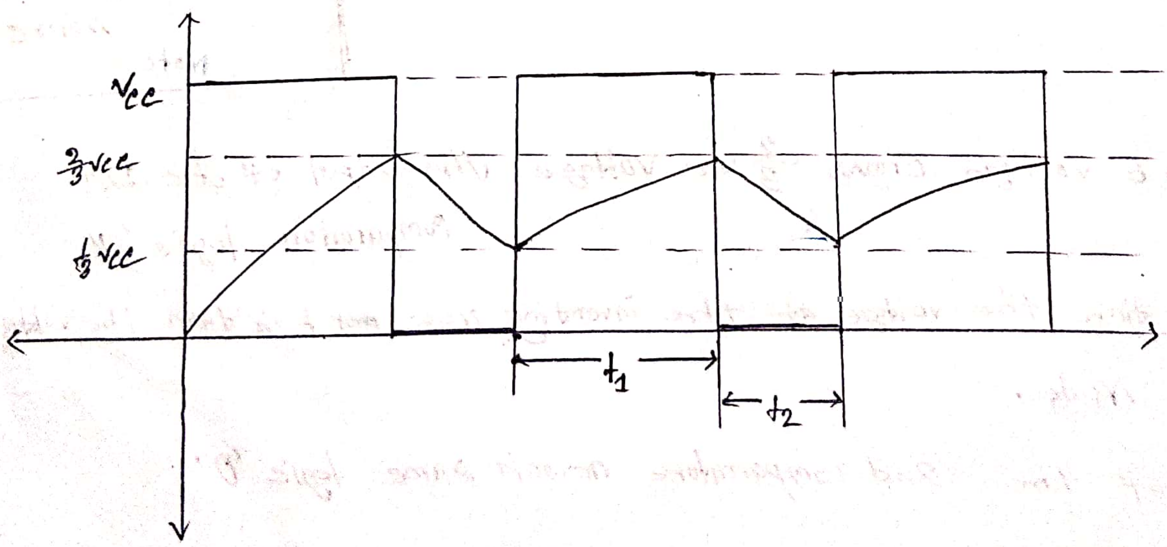
$S=0$, $R=0$, $Q=0$ & $\bar{Q}=1$

⇒ Whenever the voltage at pin 2 < $\frac{1}{3}$Vcc, then the output of the 2nd comparator logic '1'

1st comparator output remain same logic $R=0$

$S=1$, $R=0$, $Q=1$ & $\bar{Q}=0$

As soon as $\bar{Q}=0$, the transistor will get off. The capacitor again charging through R_1 and R_2.



$t_1 \rightarrow$ Charge through R_1 & R_2 $\frac{1}{3}V_{cc}$ to $\frac{2}{3}V_{cc}$ voltage.

$t_2 \rightarrow$ discharge " R_2 $\frac{2}{3}V_{cc}$ to $\frac{1}{3}V_{cc}$ voltage

So,

$$t_1 = 0.693(R_1+R_2)C \qquad \boxed{t_1 > t_2}$$

$$t_2 = 0.693 R_2 C$$

Total time,

$$T = t_1 + t_2$$

$$= 0.693(R_1+R_2) + 0.693 R_2$$

$$= 0.693(R_1 + 2R_2)C.$$

Duty cycle,

$$= \frac{\text{On time pulse}}{\text{Total time}}$$

$$= \frac{t_1}{T} = \frac{0.693(R_1+R_2)}{0.693(R_1+2R_2)}$$

$$\boxed{\text{Duty cycle} = \frac{R_1+R_2}{R_1+2R_2}}$$

That's why the Duty cycle more than the 50%

⇒ To get 50% cycle the value of $\boxed{R_1}$ should be zero,

when, $R_1 = 0$, then. Duty cycle $= \frac{R_2}{2R_2} = \frac{1}{2} = 50\%$

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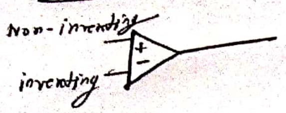
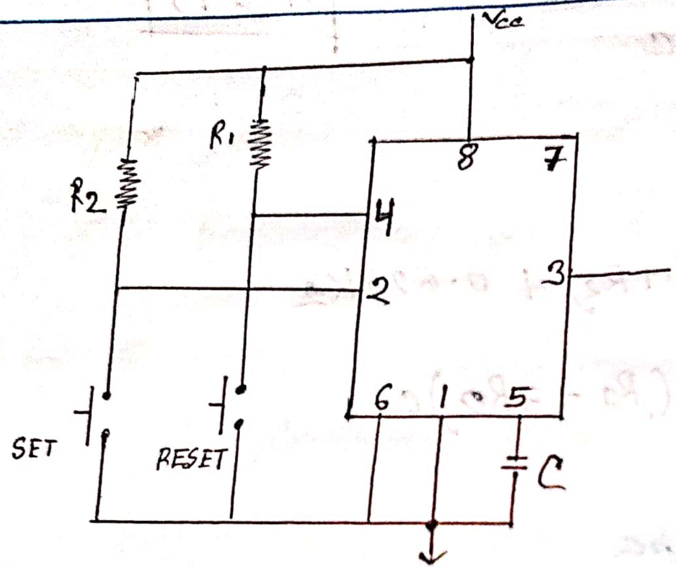
555 timer as Bistable Multivibrator

Note:

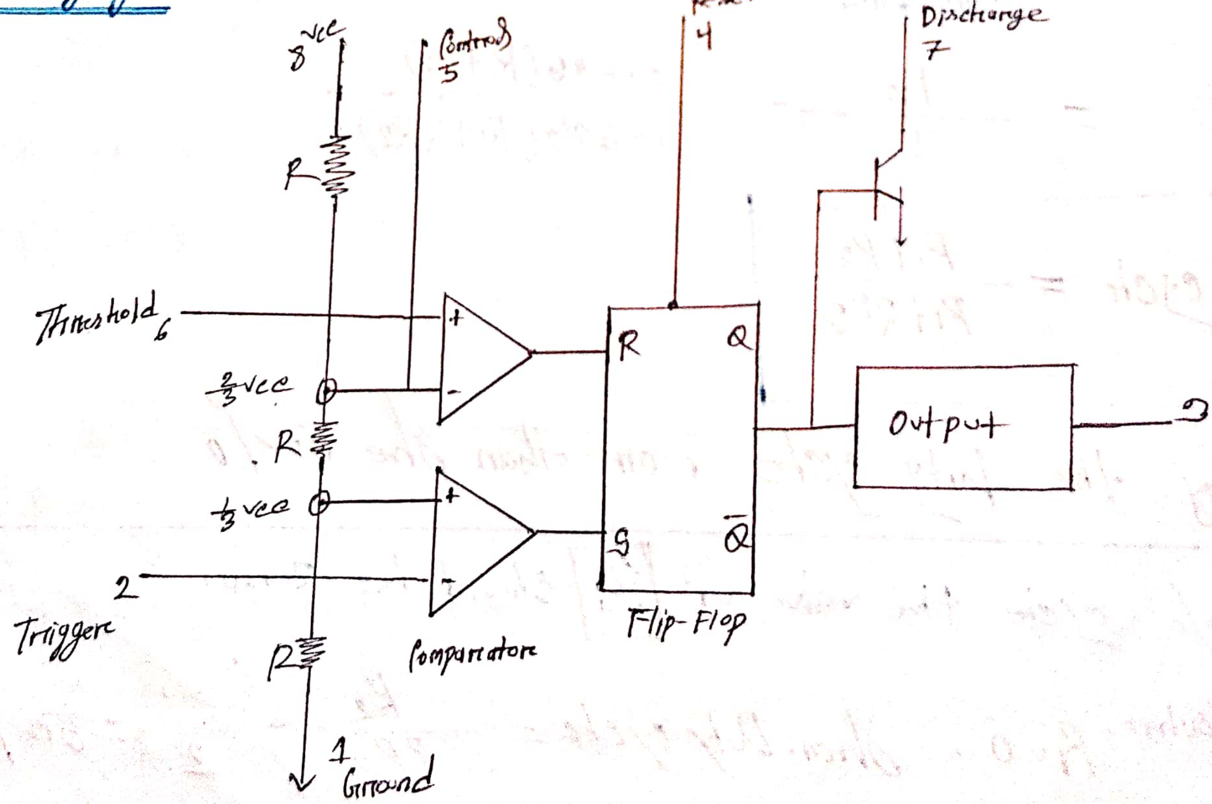


Condition

- If, Non-inverting < inverting [logic '0']
- else if, Non-inverting > inverting [logic '1']



Block Diagram



Working Procedure: $\frac{2}{3}V_{cc}$ & $\frac{1}{3}V_{cc}$ are reference voltage

⇒ Threshold voltage connect to the ground, that's why ~~...~~ voltage at node 6 < $\frac{2}{3}V_{cc}$ voltage

So, the 1st comparator output logic '0'

The trigger pin connected to the supply voltage. So voltage at node 2 > $\frac{1}{3}V_{cc}$ voltage

So, the 2nd comparator output logic '0'

Here, $S=0$ and $R=0$, $Q=0$ & $\bar{Q}=1$

⇒ When press the SET pin, then pin 2 connected to the ground potential

So, voltage at pin 2 < $\frac{1}{3}V_{cc}$ & output logic '1'

1st comparator output remain same logic '0'

Here, $S=1$ and $R=0$, $Q=1$ & $\bar{Q}=0$

⇒ Whenever trigger pin is pressed, at that time

$S=1$ and $R=0$, $Q=1$

⇒ Once the switch is realeased then once again voltage at pin 2 equal to supply voltage.

$S=0$ & $R=0$, $Q=1$

⇒ When press the RESET then pin 4 connected to the ground terminal,

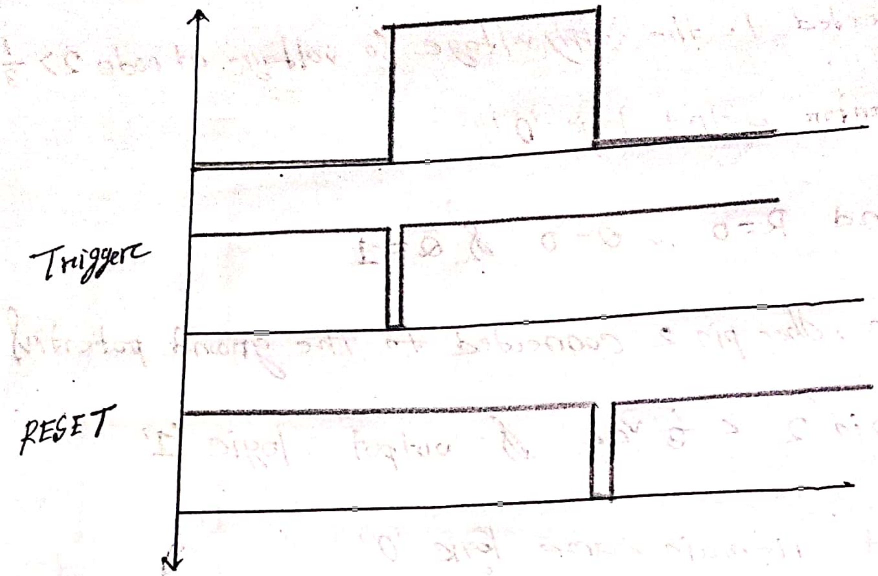
[redacted] Reset $=0$

$Q=0$

P.T.O

⇒ Realeased the RESET pin,

$S=0$ & $R=0$, $Q=0$



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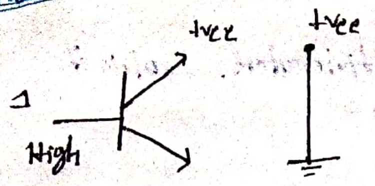
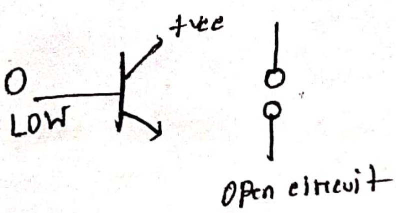
npn

Note



• If we applied High voltage (1) in any transistor Base, then it goes to [Saturation Region] And start Conduct.

$V_C = \downarrow\downarrow$ Minimum



• If we Applied [Low voltage (0)] in any transistor Base, then it goes to cut off state.

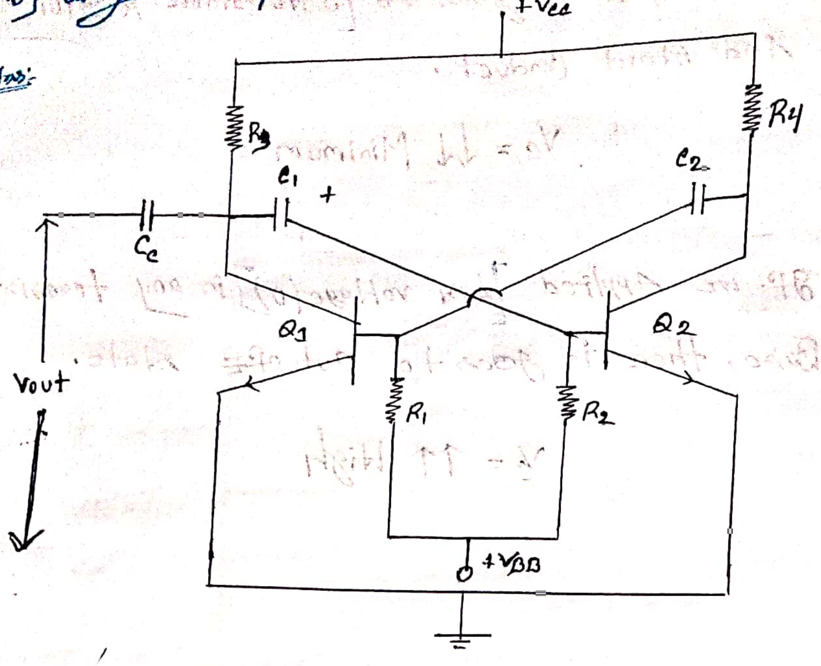
$V_C = \uparrow\uparrow$ High

Pitro

npn Astable

(12) By using two npn transistors draw an Astable Multivibrator. Explain

Ans:



Two ~~tran~~ transistor Q_1 & Q_2. $Q_1 \neq Q_2$

if Vcc start supply either Q_1 or Q_2 will conduct.

⇒ Assume, Q_1 conduct first, & it goes to saturation region.

that's why V_c = minimum ↓↓

⇒ Decrease voltage V_c Apply to Base Q_2

· if we applied low voltage into Base transistor, then it goes to cut off state.

That's why V_c = High ↑↑

→ Increase voltage applied to Base Q1
If we applied high voltage into Base transistor, then it goes to saturation Region, that's why V_C = minimum ↓↓

After some time Q1 completely goes to saturation Region &

Q2 " " " Cut off "

→ then $+V_{BB}$ supply current. As Q2 is cut off region,

the current I pass through capacitor C_1. Then Capacitor C_1

start charging.

→ The High voltage apply to Base Q2, As we know then transistor

move to ~~sta~~ saturation Region.

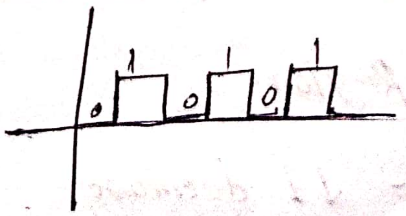
that's why V_C = ↓↓

→ The decrease voltage ve apply to Base Q1, then Q1

move to cut off region.

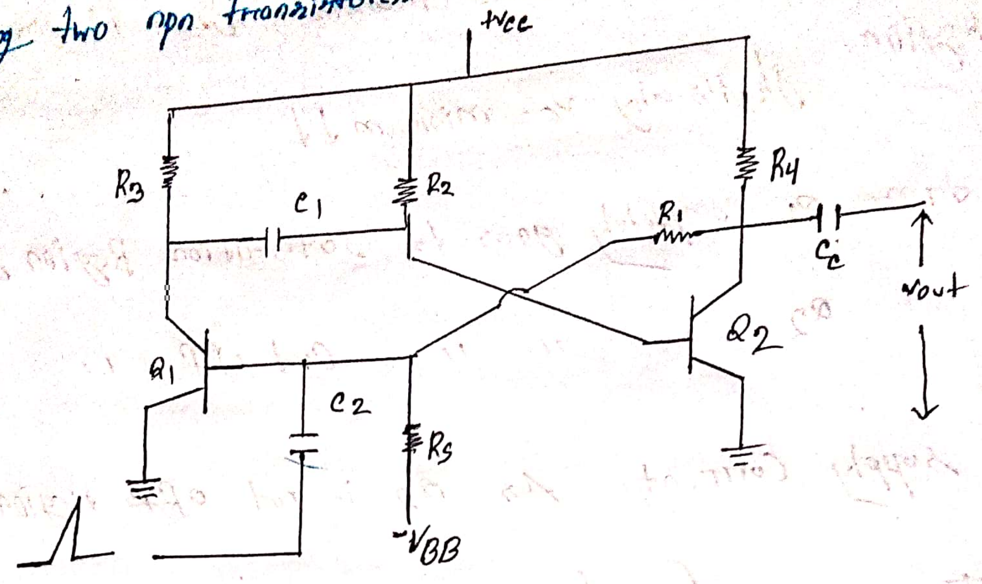
that's why V_C = ↑↑

Output



(21) By using two npn transistors draw a Monostable Multivibrator, Explain

Ans:



For $-V_{BB}$, transistor Q_1 goes to cut off state

Because $-V_{BB}$ low voltage Apply to the Base of Q_1

So, $V_C = \uparrow\uparrow$ ~~increase~~ increase.

The increase V_C voltage apply to the Base transistor Q_2.

that's why transistor Q_2 ~~goes~~ goes to saturation Region.

So, $V_C = \downarrow\downarrow$ decrease.

Trigger → short duration High pulse

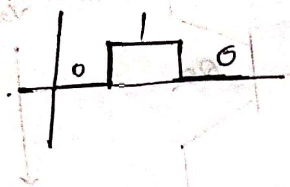
when we trigger the circuit to transistor Q_1, then Q_1 goes to saturation Region.

$V_C = \downarrow\downarrow$ decrease.

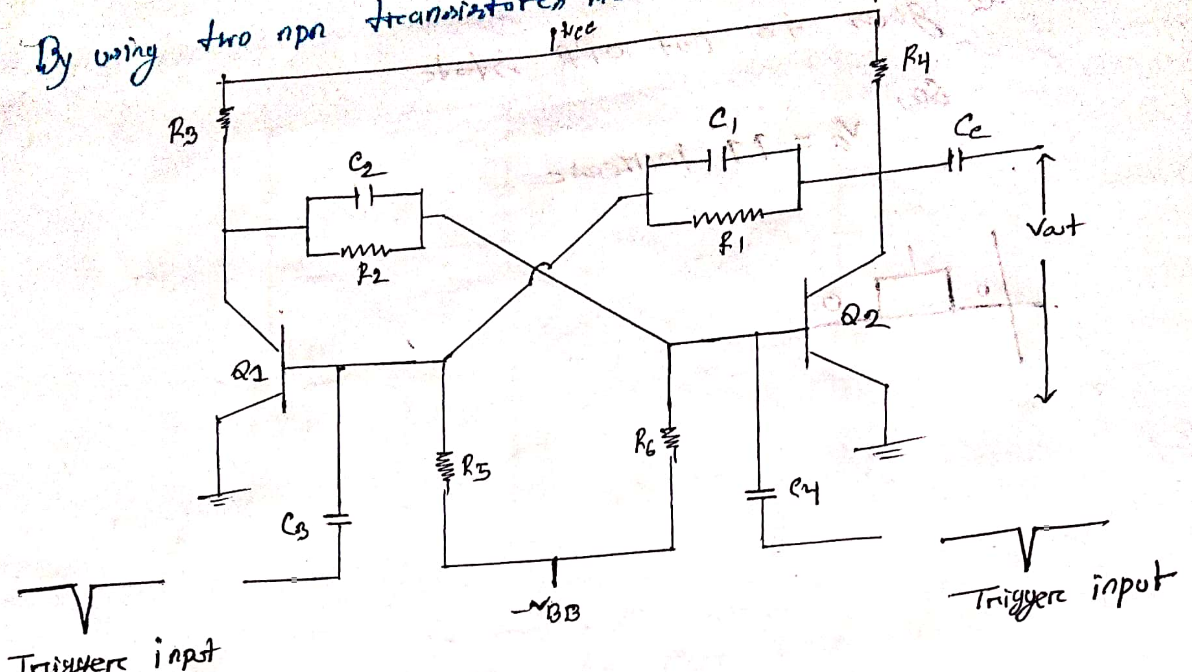
The decrease voltage apply to Base Q_2

then Q_2 goes to cut off state

So, $V_e = \uparrow\uparrow$ increase



(18) By using two npn transistors make a Bi-stable Multivibrator. Explain it.



When +Vcc supply start then Q2 transistor start conduct,

So $V_C = \downarrow\downarrow$ decrease

the decrease voltage V_C apply to Base Q1, So, Q1 will goes to cut off state,

So, $V_C = \uparrow\uparrow$ increase

when we applied negative trigger in Q2 transistor. then Q2 go to cut off region.

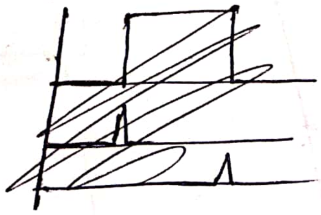
$V_C = \uparrow\uparrow$ increase.

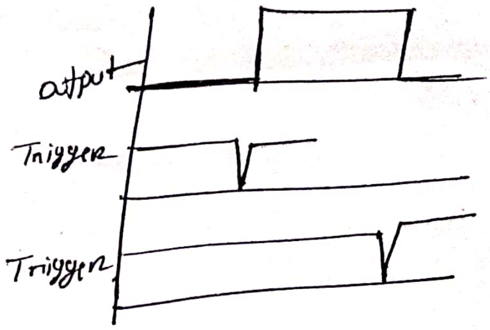
Again Applied Negative pulse trigger in Q_1, then Q_1 goes to cut off state

So, V_e = ↑↑ increase

the increase V_c applied in Q_2 base, So, that's why Q_2 more cut off to saturation region.

So, V_e = ↓↓ decrease.





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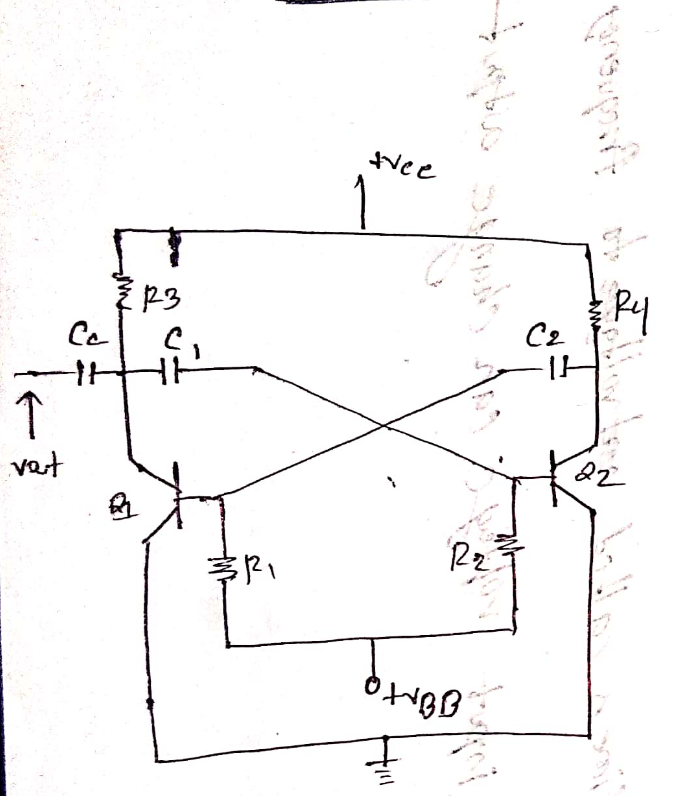
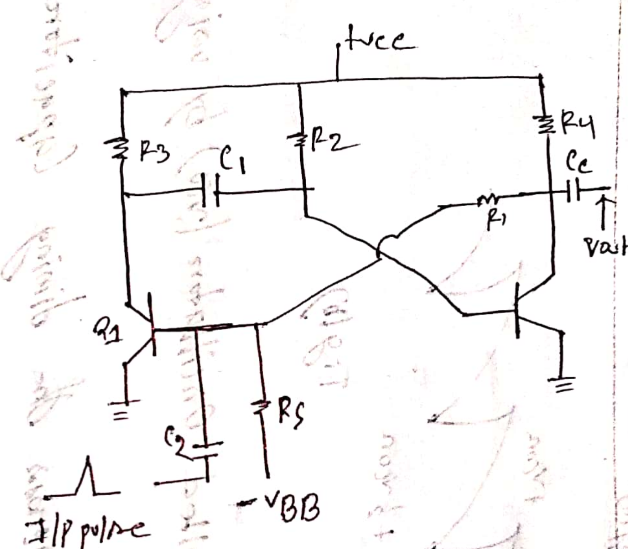
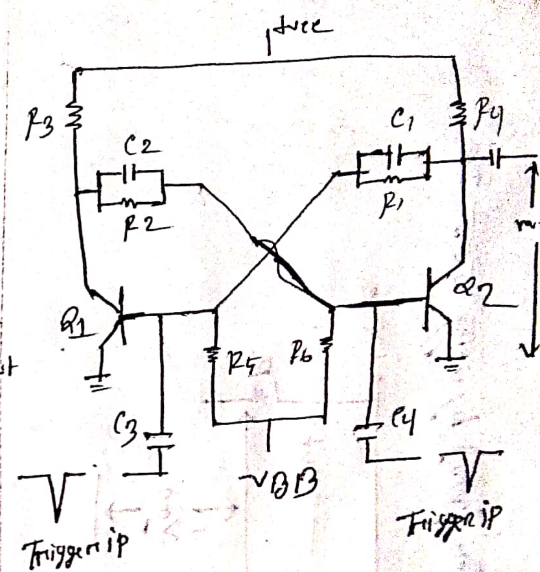
Astable



Monostable

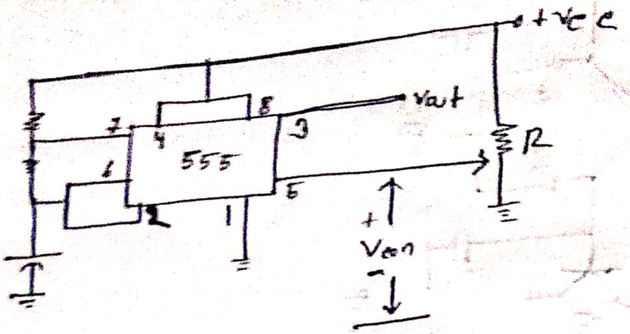


Bistable

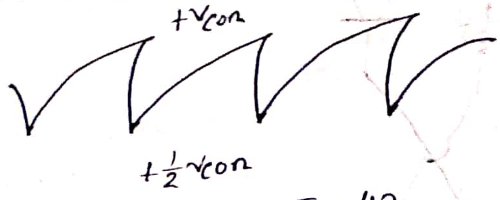


(13) Make a voltage Controlled Oscillator (VCO) by using 555 IC

Ans:



Fig(a)



Fig(b)

Fig(a) shows a voltage Controlled Oscillator (VCO) by using 555 IC.

Fib(b) shows the " ~~are~~ across the timing Capacitor

This circuit is sometimes called ~~vat~~ voltage to frequency Converter. Because an input voltage can change output frequency.

pin-5 connect to the inverting input of the upper comparator

Normally the control voltage is $\frac{2}{3}Vcc$ because of the internal voltage divider.

By applying a voltage ~~_~~ in control pin, we can override the internal voltage.

if we increase +Vcontrol it takes the capacitor longer ~~longer~~ to charge & discharge.

Therefore the frequency decrease.

As a result, we can change the frequency of the circuit by varying the control voltage.

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(14) Drive the eqn for calculating output frequency of astable MV.

Soln

Capacitor voltage ~~sat~~ starts at $\frac{1}{3}V_{cc}$ and ends at $\frac{2}{3}V_{cc}$ and target voltage of $+V_{cc}$

We know ⇒ $V = V_i + (V_f - V_i)(1 - e^{-t/RC})$

V = capacitor voltage

V_i = initial capacitor voltage.

V_f = target " "

So,

$$\frac{2}{3}V_{cc} = \frac{1}{3}V_{cc} + \left(V_{cc} - \frac{1}{3}V_{cc}\right)\left(1 - e^{-t/RC}\right)$$

$$\Rightarrow \text{"} = \text{"} + \left(\frac{3V_{cc} - V_{cc}}{3}\right)\left(1 - e^{-t/RC}\right)$$

$$\Rightarrow \frac{2}{3}V_{cc} = \frac{1}{3}V_{cc} + \frac{2V_{cc}}{3}\left(1 - e^{-t/RC}\right)$$

$$\Rightarrow \frac{2}{3}V_{cc} = \frac{2V_{cc}}{3}\left[\frac{1}{2} + \left(1 - e^{-t/RC}\right)\right]$$

$$\Rightarrow 0 = \frac{1}{2} + \left(1 - e^{-t/RC}\right)$$

$\Rightarrow -\frac{1}{2} = (1-e^{-t/Rc})$

$\Rightarrow -.5 = 1 - e^{-w/Rc}$

$\Rightarrow -1.5 = -e^{-w/Rc}$

$\Rightarrow -w/Rc = -.693$

$\Rightarrow w = .693RC$

Charging $t_1 = (R_A+R_B)c \cdot .693$

Discharging $t_2 = .693 R_B c$

$T = t_1 + t_2$

$= .693(R_A+2R_B)c$

Duty cycle: $\frac{t_1}{T} = \frac{.693(R_A+R_B)c}{.693(R_A+2R_B)c} = \frac{R_A+R_B}{R_A+2R_B} \times 100\%$

Frequency; $f = \frac{1}{T} = \frac{1}{.693(R_A+2R_B)c}$