G. Venkata Hanuman
Asst. Prof.

4. Mono stable multivibrator

A mono stable multivibrator has one stable state and other is quasi stable state.

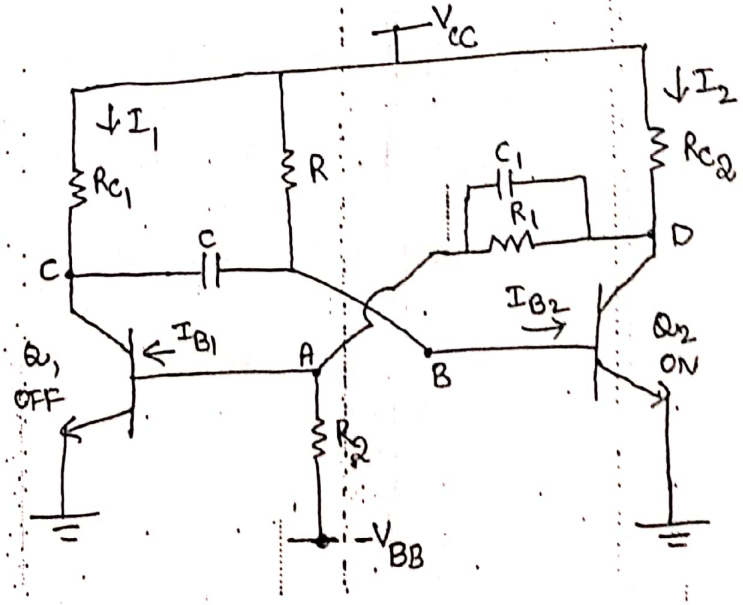
A triggering signal is required to induce a transition from one stable state to quasi stable state. No external triggering signal is ~~appli~~ required to induce reverse transition.

In this, one coupling element is resistor and another coupling element is capacitor.

It is also known as one-shot, single step, univibrator, gating circuit (or) delay circuit.

collector coupled monostable multivibrator :-

The collector coupled monostable multivibrator is shown in fig. below



www.Jntufastupdates.com Scanned with CamScanner

In this, the collector of Q_2 is coupled to the base of Q_1 by resistor R_1 (dc coupling) and collector of Q_1 is coupled to the base of Q_2 by capacitor C (A.C coupling)

The commutating capacitor C_1 is Introduced to Increas the speed of operation.

The base of Q_1 is connected to $-V_{BB}$ through resistor R_2 to ensure that Q_1 is cut-off. the base of Q_2 is connected to V_{cc} through the resistor R to ensure that Q_2 is saturation

when -ve signal is applied at the base of Q_2 at $t=0$, due to regenerative action Q_2 goes OFF and Q_1 goes to ON.

when Q_1 is ON, the current I_1 flows through its resistance R_{C1}, hence collector voltage drops by $I_1 R_{C1}$. This drop is transmitted to the base of Q_2 through coupling capacitor 'C'.

at $t=0^+$, the base voltage of Q_2 is $V_{BE(sat)} - I_1 R_{C1}$.

when Q_1 conducts, the capacitor 'c' charges from V_{cc} through transistor Q_1 and hence the potential at the base of Q_2 rises exponentially with time constant $Rc = (R+R_0)C$ where R_0 is conducting transistor output Impedance Including R_c.

www.Jntufastupdates.com Scanned with CamScanner

when it passes the cut-in voltage V_γ to base of Q_2 then the transistor goes to ON state and output voltage reduces i.e, applied to base of Q_1 then Q_1 goes to OFF state.

At t=0, the transition changes from stable state to Quasi stable state. At t=T, the transition changes from Quasi stable state to stable state.

The time 'T' for which the circuit is in it's Quasi stable state is referred to as delay time (or) pulse width (or) gate time (or) pulse duration.

Expression for pulse width (or) delay time (T):-

FOR $t<0$, Q_2 is ON and $V_{B2} = V_{BE(sat)}$.

FOR $t=0$, a negative signal is applied it makes Q_2 OFF, Q_1 ON. V_{C1} drops by $I_1 R_{C1}$ and V_{B2} drops by $I_1 R_{C1}$ and

$$V_{B2} = V_{BE(sat)} - I_1 R_{C1}$$

FOR $t>0$, capacitor charges with time constant RC so the base voltage of Q_2 rises exponentially to V_{CC}.

At t=T, base voltage rises to cut-in voltage V_γ. If $V_{B2} > V_\gamma$ then the transistor Q_2 goes to ON and Q_1 goes to OFF.

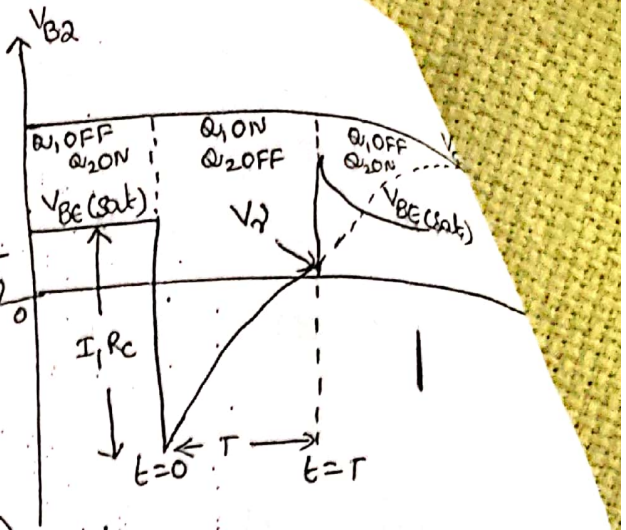
www.Jntufastupdates.com Scanned with CamScanner

The base voltage of Q_2 at $t=T$ is,

$$V_{B2} = V_{cc} - [V_{cc} - (V_{BE(sat)} - I_1 R_C)) e^{-t/\tau}$$

$[\because V_B = V_{fin} - (V_{fin} - V_{ini}) e^{-t/\tau}]$

But $I_1 R_C = V_{cc} - V_{CE(sat)}$.



$$V_{B2} = V_{cc} - \left[V_{cc} - \left(V_{BE(sat)} - (V_{cc} - V_{CE(sat)})\right)\right] e^{-t/\tau}$$

$$= V_{cc} - (V_{cc} - (V_{BE(sat)} - V_{cc} + V_{CE(sat)})) e^{-t/\tau}$$

$$= V_{cc} - (V_{cc} - V_{BE(sat)} + V_{cc} - V_{CE(sat)}) e^{-t/\tau}$$

$$= V_{cc} - (2V_{cc} - (V_{BE(sat)} + V_{CE(sat)})) e^{-t/\tau} \quad \text{— (1)}$$

At $t=T$; $V_{B2} = V_\gamma$

then eq (1), becomes

$$V_\gamma = V_{cc} - (2V_{cc} - (V_{BE(sat)} + V_{CE(sat)})) e^{-T/\tau}$$

$$\Rightarrow 2V_{cc} - (V_{BE(sat)} + V_{CE(sat)}) e^{-T/\tau} = V_{cc} - V_\gamma$$

$$\Rightarrow e^{-T/\tau} = \frac{2V_{cc} - V_\gamma}{2\left[V_{cc} - \frac{V_{BE(sat)} + V_{CE(sat)}}{2}\right]}$$

$$\Rightarrow e^{T/\tau} = \frac{2\left[V_{cc} - \frac{V_{BE(sat)} + V_{CE(sat)}}{2}\right]}{V_{cc} - V_\gamma}$$

$$\Rightarrow \frac{T}{\tau} = \frac{\ln\left(2\left(V_{cc} - \frac{V_{BE(sat)} + V_{CE(sat)}}{2}\right)\right)}{V_{cc} - V_\gamma}$$

www.Jntufastupdates.com Scanned with CamScanner

$$\Rightarrow T = \tau \ln 2 + \tau \ln \frac{V_{CC} - \frac{V_{BE(sat)} + V_{CE(sat)}}{2}}{V_{CC} - V_\gamma} \quad \text{—②}$$

At room temperature cut-in voltage is the average of saturation junction voltages for Si (or) Ge transistors.

$$\text{i.e } V_\gamma = \frac{V_{CE(sat)} + V_{BE(sat)}}{2}$$

Neglect second term in eq ②,

$$T = \tau \ln 2$$

$$T = (R + R_0)C \ln 2 = 0.693\,RC \qquad (\because R_0 << R)$$

$$\therefore \boxed{\text{Gate width, } T = 0.693RC}$$

waveforms of collector-coupled monostable multivibrator :-

Stable state :- FOR $t<0$ $\therefore Q_2 \rightarrow$ ON , Q_1 OFF

Q_2 ON , SO base voltage $V_{B2} = V_{BE2(sat)}$

collector voltage $V_{C2} = V_{CE2(sat)}$

Q_1 OFF , No current flows.

The collector voltage of Q_1 is $V_{C1} = V_{CC}$

Base Voltage of Q_1 using super position theorem

$$V_{B1} = -V_{BB} \frac{R_1}{R_1 + R_2} + V_{CE2(sat)} \frac{R_2}{R_1 + R_2}$$

www.Jntufastupdates.com Scanned with CamScanner

Quasi-stable state:-

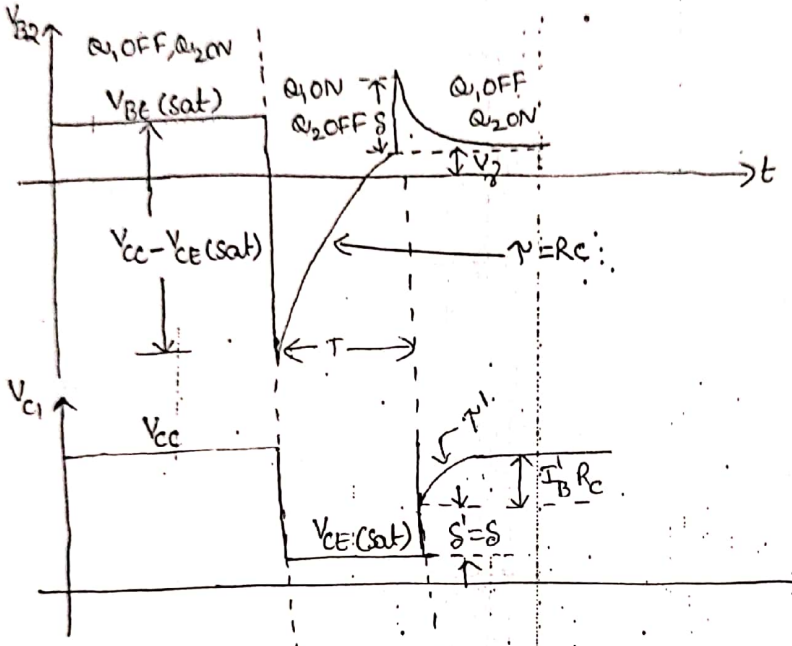
-ve trigger signal applied at $t=0$ brings Q_2 OFF ;

Q_1 ON.

Q_1 ON $\rightarrow$ $V_{B1} = V_{BE1}(sat)$ and $V_{C1} = V_{CE1}(sat)$

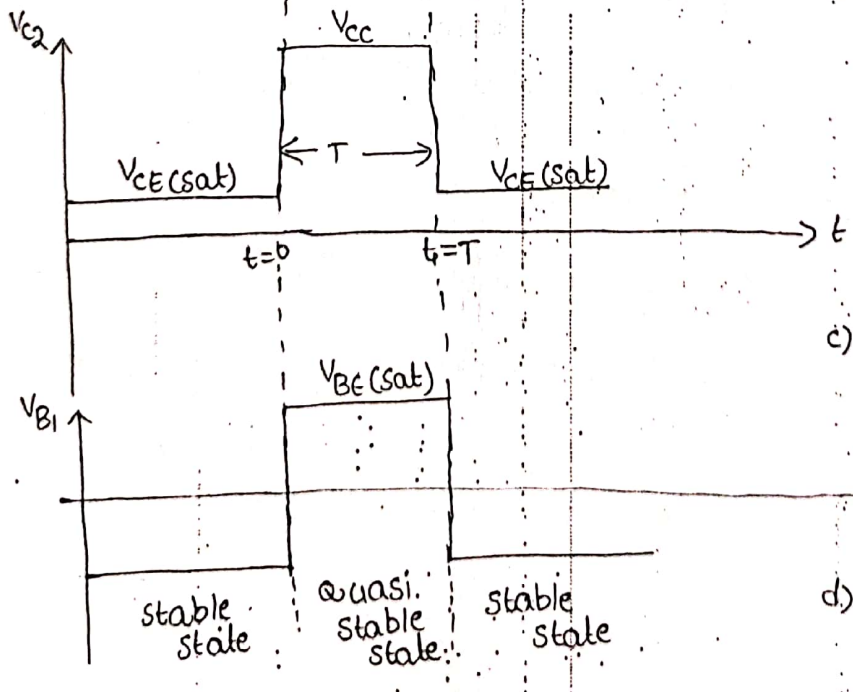
Q_2 OFF $\rightarrow$ $V_{B2} = V_{BE2}(sat) - I_1 R_C$

$$V_{C2} = V_{CC}\frac{R_1}{R_1+R_C} + V_{BE1}(sat)\frac{R_C}{R_1+R_C}$$



a) At Base of Q_2

b) At collector of Q_1



c) At collector of Q_2

d) At Base of Q_1

www.Jntufastupdates.com Scanned with CamScanner

Waveform for $t>T$:-

At $t=T^+$, reverse transition takes place. Q_2 conducts and Q_1 cut-off.

To replace Input circuit of Q_2 by Base spreading resistance r'_{BB} in series with voltage $V_{BE(sat)}$ as shown in fig. below

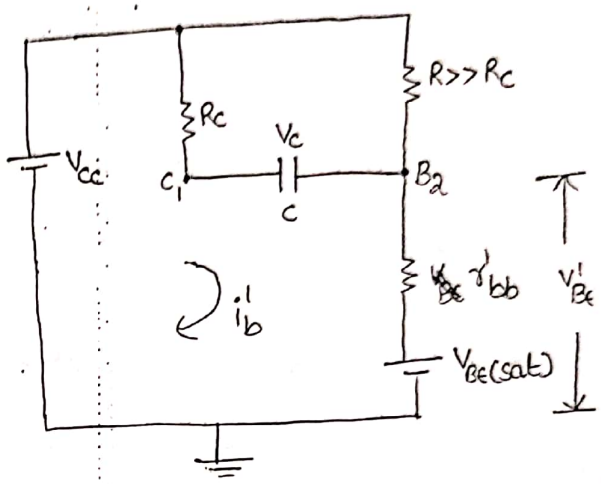


Fig:- Equivalent circuit for caluclating overshoot at Base B_2 of Q_2

From fig.

$$V'_{BE} = I'_b r'_{bb} + V_{BE(sat)}$$

$$V_c = V_{cc} - I'_b R_c - V'_{BE}$$

The Jumps in voltages at B_2 and C_1 are given by

$$\delta = V'_{BE} - V_\gamma = I'_b r'_{bb} + V_{BE(sat)} - V_\gamma$$

$$\delta' = V_{cc} - V_{CE(sat)} - I'_b R_c$$

C_1 & B_2 are connected by capacitor 'C'.

Equating δ & δ', we get.

$$I'_b r'_{bb} + V_{BE(sat)} - V_\gamma = V_{cc} - V_{CE(sat)} - I'_b R_c$$

$$I'_b = \frac{V_{cc} - V_{CE(sat)} - V_{BE(sat)} + V_\gamma}{R_c + r'_{bb}}$$

consider Time constant $\tau' = (R_c + r'_{bb})C$ as shown in output waveform (b).

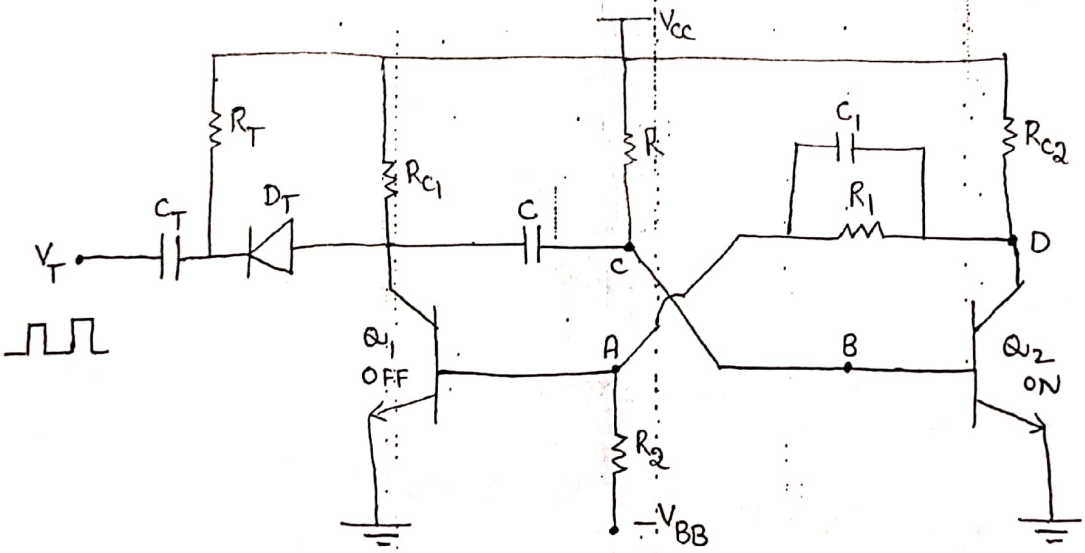
www.Jntufastupdates.com Scanned with CamScanner

Triggering of mono stable multivibrator :-

A monostable multivibrator needs triggered by a suitable signal, in order to switch from stable state to quasi stable state. However, after remaining in quasi stable state for some time, it automatically switched back to original state without triggering.

A monostable multivibrator requires only one triggering signal. In this, Asymmetrical triggering technique is used.

The circuit diagram of one shot multivibrator employing collector triggering mechanism as shown in fig.



The triggering pulse in the form of +ve and -ve spikes obtained R_T & C_T form RC High pass circuit i.e differentiator.

when a negative spike applied at the base of Q_2 that is transmitted to output V_T through capacitor.

www.Jntufastupdates.com Scanned with CamScanner

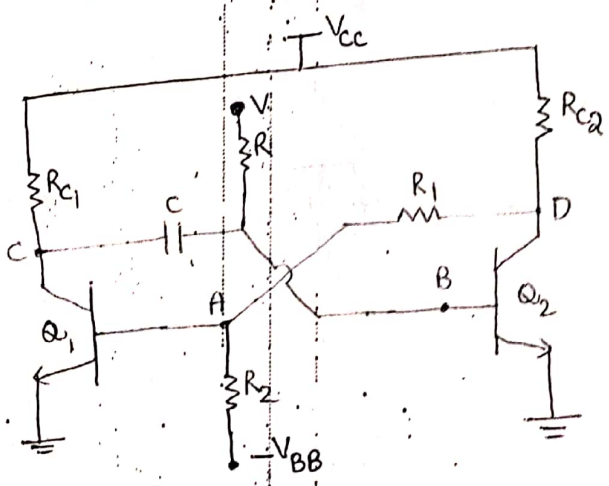
Diode D_T conducts.

The transistor Q_2 is OFF, Immediately Q_1 becomes ON then the monostable multivibrator switched into quasi stable state.

Note :- Symmetrical triggering is not needed for monostable multivibra

Monostable multivibrator as voltage to time converter :-

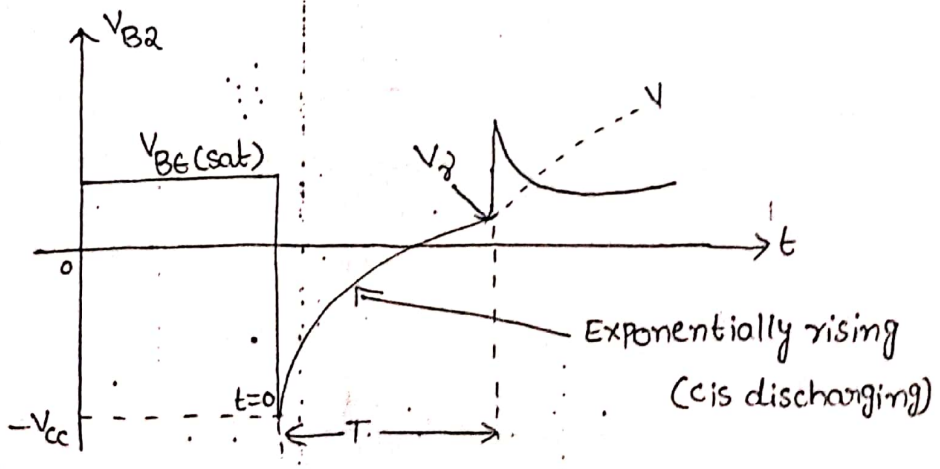
In this circuit diagram, Resistor R is connected to an auxilary voltage source V instead of V_{cc}.



Q_1 – Normally OFF

Q_2 – Normally ON

The wave form of voltage V_{BB} V_{B2} at base of Q_2 as shown in fig. below



www.Jntufastupdates.com Scanned with CamScanner

From fig, the base of V_{B2} of Q_2 rises exponentially from $-V_{cc}$ as capacitor 'c' progressively discharges, until becomes equal to V_γ.

when $V_{B2} = V_\gamma$ at end of gate time, Q_2 ON instantly, with that result V_{B2} cannot increase further to V.

$V_{initial} = -V_{cc}$, $V_{final} = V$, $t = T$, $V_0 = V_{B2}$

we know that,

$$V_0 = V_f - (V_f - V_{in})\, e^{-t/RC}$$

$$V_{B2} = V - (V + V_{cc})\, e^{-T/RC} \quad \text{—①}$$

At $t = T$, $V_{B2} = V_\gamma = 0V$;

eqn① changes to $0 = V - (V + V_{cc})\, e^{-T/RC}$

$$(V + V_{cc})\, e^{-T/RC} = V \Rightarrow e^{-T/RC} = \frac{V}{V + V_{cc}}$$

$$\Rightarrow e^{T/RC} = \frac{V + V_{cc}}{V}$$

$$\Rightarrow T/RC = \ln\left(\frac{V + V_{cc}}{V}\right)$$

$$\Rightarrow T/RC = \ln\left(1 + \frac{V_{cc}}{V}\right)$$

$$\Rightarrow \boxed{T = RC \ln\left(1 + \frac{V_{cc}}{V}\right)} \quad \text{—②}$$

From eqn②,

× The Pulse 'T' is a function of auxilary voltage V.

For this reason, the mono-stable multivibrator is termed as voltage to time converter (V-T converter).

www.Jntufastupdates.com Scanned with CamScanner

Astable multivibrator

In Astable multivibrator, both the states are Quasi stable states. It keeps oscillating between two Quasi stable states and it is connected to supply.

Both the coupling elements are capacitors (A.C coupling) No triggering signal is required. It is also known as free running multivibrator (or) master oscillator.

It generates square wave, so it is called as square wave generator (or) square wave oscillator (or) Relaxation oscillator.

collector-coupled Astable multivibrator :-

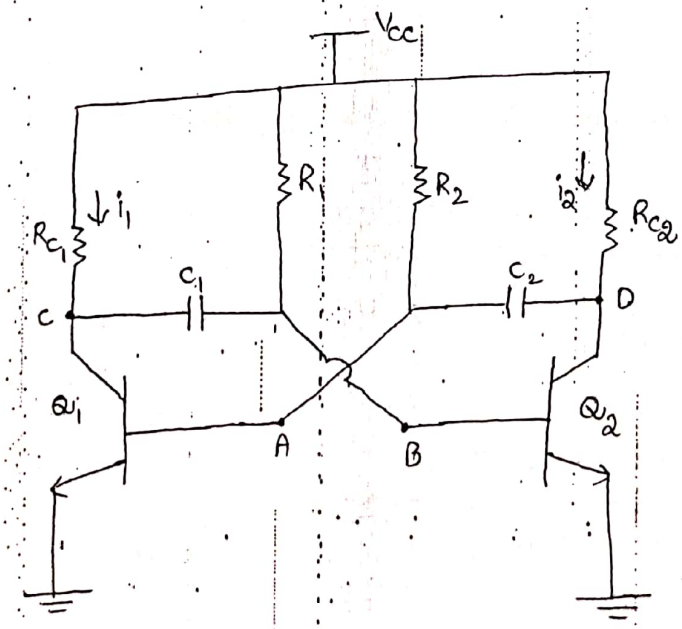


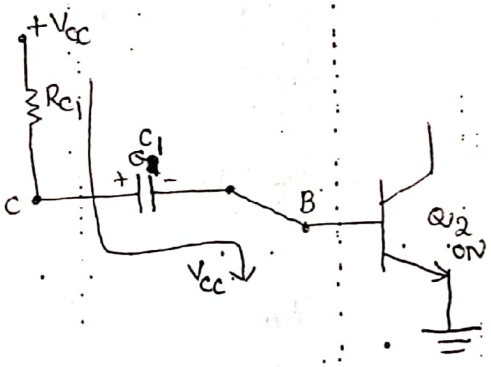
Fig :- collector-coupled Astable multivibrator

www.Jntufastupdates.com Scanned with CamScanner

The collectors of both transistors Q_1, Q_2 are connected base of other transistors through coupling capacitors C_1 & C_2 both are A.C coupling.

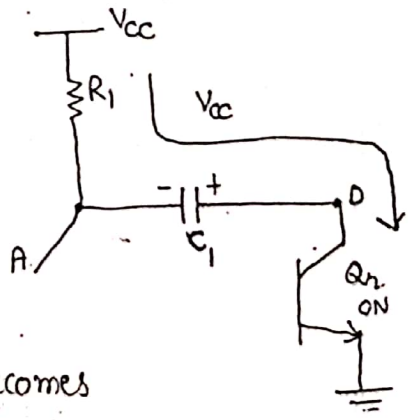
It has 2 Quasi stable states and it keeps on charging (or) switch between the states by itself. No external triggering is required.

i) At t=0, (or) Initially the transistor Q_1 is OFF and Q_2 is ON Q_2 is ON, capacitor C_1 charges through resistor R_{C_1}. The voltage across C_1 is V_{cc}. The voltage across C_2 is V_{cc}.



ii) As the capacitor C_1, discharges through resistor R_1,

The voltage across C_1 when it start discharging is V_{cc}.



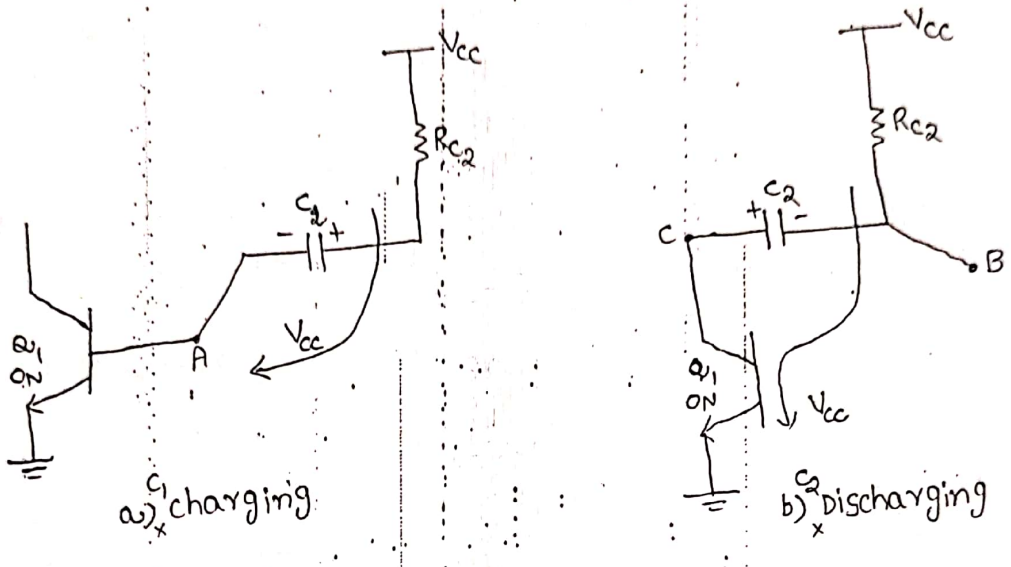
As capacitor discharges more and more, the potential of point A becomes more positive and V_A equal to V_γ.

For $V_A > V_\gamma$ transistor Q_1 is ON Q_2 becomes OFF.

www.Jntufastupdates.com Scanned with CamScanner

Similar operations, repeat when Q_1 ON and Q_2 OFF.

Q_1 ON & Q_2 OFF, capacitor C_2 charges through resistor R_{C2} and capacitor C_2 discharges through resistor R_2.

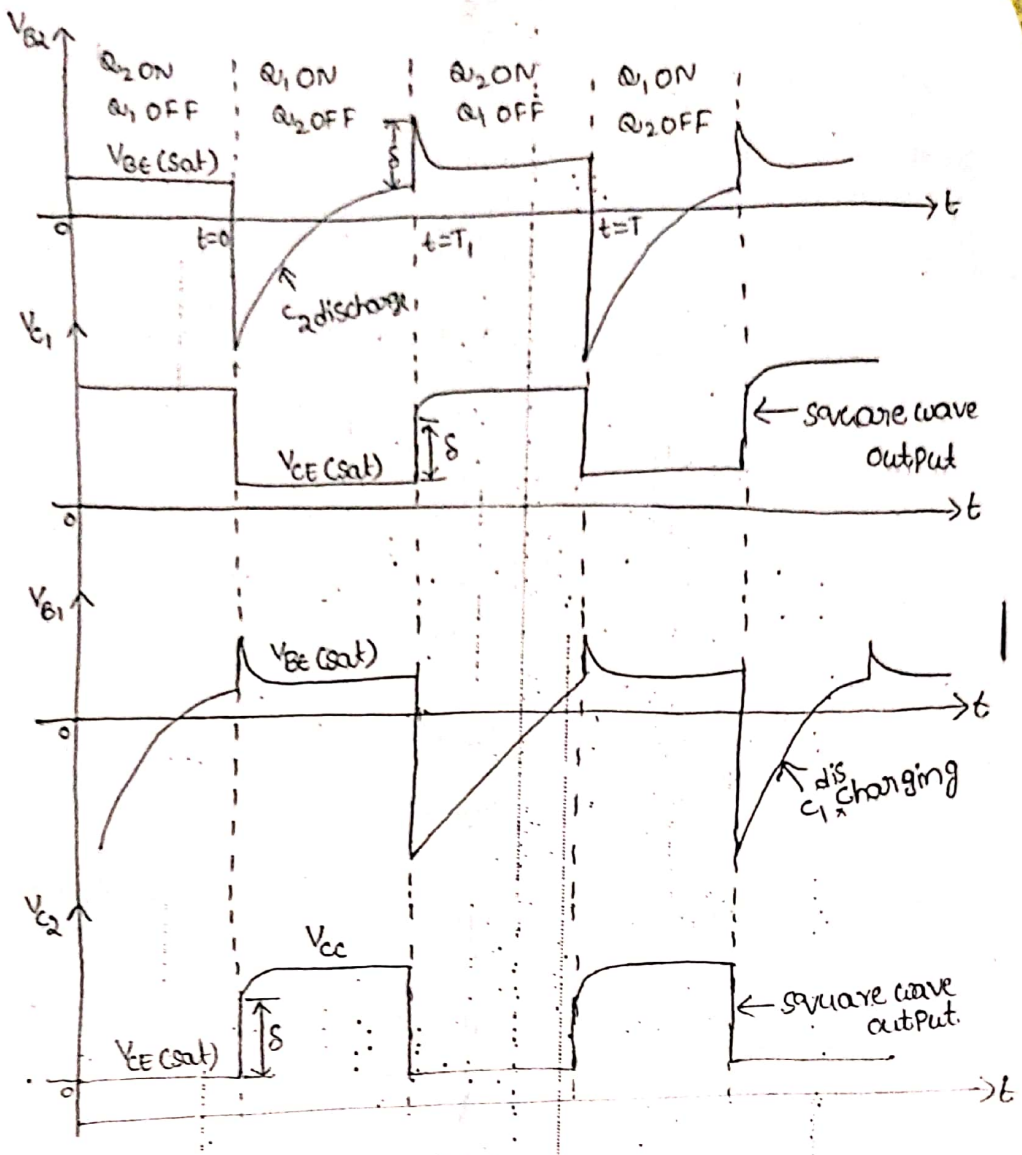


As capacitor C_2 discharging more and more, the potential at point B less and less negative ∴ eventually V_B becomes equal to V_γ. when $V_B > V_\gamma$, transistor Q_2 becomes ON. Q_1 becomes OFF.

The circuit keeps on switching continuously between 2 Quasi-stable states and no external triggering is needed. square wave voltages are generated at collector terminals of Q_1 and Q_2 i.e Points C and D.

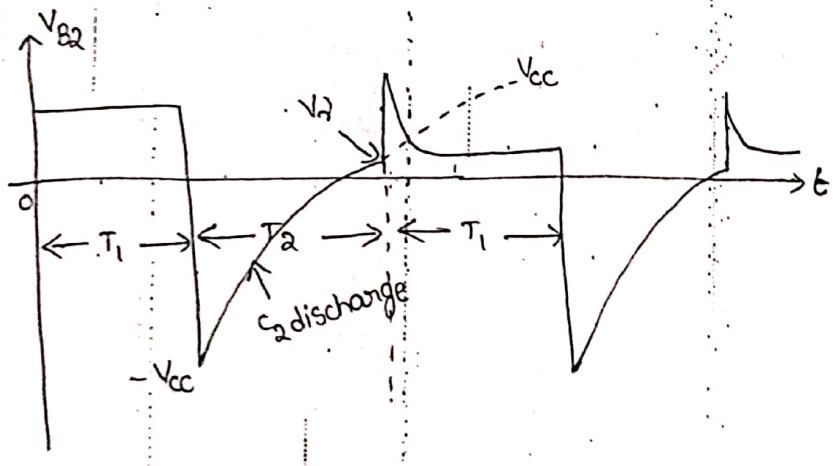
The Input and output waveforms as shown in fig.

www.Jntufastupdates.com Scanned with CamScanner



Expression for frequency of oscillation of an Astable multivibrator

(or) Expression for pulse width :-



www.Jntufastupdates.com Scanned with CamScanner

At V_{B2}, FOR $0<t<T_1$,

$V_i = -V_{cc}$, $V_f = V_{cc}$, $t = T_1$, $V_0 = V_{B2}$

$V_0 = V_f - (V_f - V_{ini})\, e^{-t/RC}$

$\Rightarrow V_{B2} = V_{cc} - (V_{cc} + V_{cc})\, e^{-T_1/R_1C_1}$ — ①

At $t = T_1$, $V_{B2} = V_2 = 0$ then eq① becomes

$0 = V_{cc} - 2V_{cc}\, e^{-T_1/R_1C_1} \Rightarrow 2V_{cc}\, e^{-T_1/R_1C_1} = V_{cc}$

$\Rightarrow 2\, e^{-T_1/R_1C_1} = 1$

$\Rightarrow e^{-T_1/R_1C_1} = \frac{1}{2}$

$\Rightarrow e^{T_1/R_1C_1} = 2$

$\Rightarrow T_1/R_1C_1 = \ln 2$

$\Rightarrow T_1 = 0.693\, R_1C_1$ — ②

At V_{B1}, FOR $T_1<t<T$,

$V_i = -V_{cc}$, $V_f = V_{cc}$, $t = T - T_1$

$\Rightarrow V_{B1} = V_{cc} - (V_{cc} + V_{cc})\, e^{-(T-T_1)/R_2C_2}$ — ③

At $t = T$, $V_{B1} = V_2 = 0$ then eq③ becomes

$0 = V_{cc} - 2V_{cc}\, e^{-(T-T_1)/R_2C_2} \Rightarrow e^{-(T-T_1)/R_2C_2} = \frac{1}{2}$

$\Rightarrow (T-T_1)/R_2C_2 = \ln 2$

$\Rightarrow T = 0.693\, R_2C_2 + T_1$

$\Rightarrow T = 0.693\, R_2C_2 + 0.693\, R_1C_1$

$\Rightarrow T = 0.693\,(R_1C_1 + R_2C_2)$ — ④

www.Jntufastupdates.com Scanned with CamScanner

The above equation is for unsymmetrical square wave. But

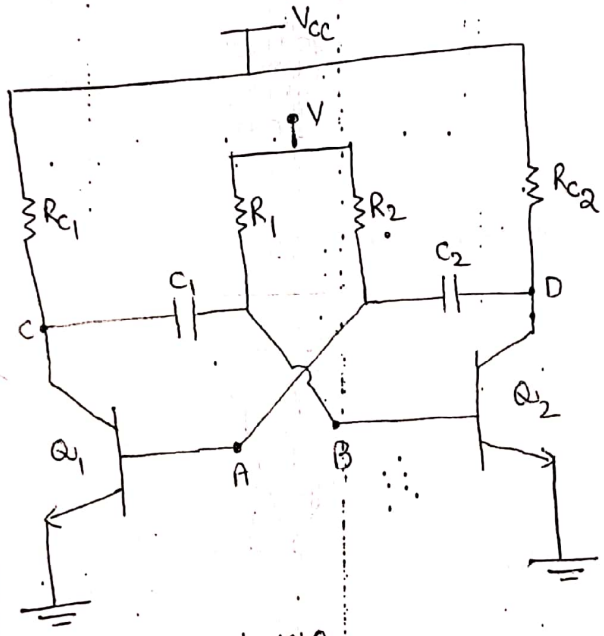
for symmetrical square wave $R_1=R_2=R$, $C_1=C_2=C$

$\Rightarrow T=0.693(2RC)$

$$\boxed{T=1.38RC}$$

The frequency of oscillations, $\boxed{f=\frac{1}{T}=\frac{1}{1.38RC}}$

Astable multivibrator as voltage to frequency converter:-

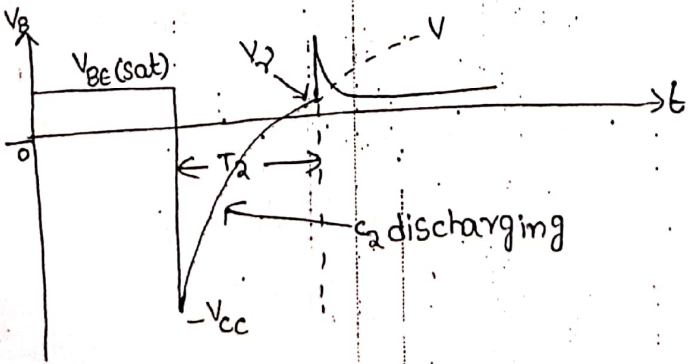


V_{CC} → Supply Volta

V → Auxilary voli

of base Q_2

The out put wave form as shown in fig.



consider $0<t<T_1$, Q_1 OFF, Q_2 ON.

www.Jntufastupdates.com Scanned with CamScanner

The voltage at base Q_1 is given by,

$V_{in} = -V_{cc}$, $V_f = V$, $V_o = V_{B1}$

$$V_{B_1} = V_f - (V_f - V_{in})\, e^{-t/\tau_1}$$

$$= V - (V + V_{cc})\, e^{-t/\tau_1}$$

At $t = T_1$, $V_{B1} = V_2 = 0$.

$$\Rightarrow 0 = V - (V + V_{cc})\, e^{-T_1/R_1C_1}$$

$$\Rightarrow V = (V + V_{cc})\, e^{-T_1/R_1C_1} \Rightarrow e^{-T_1/R_1C_1} = \frac{V}{V+V_{cc}}$$

$$\Rightarrow e^{T_1/R_1C_1} = \frac{V+V_{cc}}{V}$$

$$\Rightarrow T_1/R_1C_1 = \ln\left(\frac{V+V_{cc}}{V}\right)$$

$$\Rightarrow T_1 = \ln\left(1 + \frac{V_{cc}}{V}\right) R_1C_1 \quad \text{---(1)}$$

Similarly, base of Q_2 is $T_2 = R_2C_2 \ln\left(1 + \frac{V_{cc}}{V}\right)$ ---(2)

The period $T = T_1 + T_2$

$$= (R_1C_1 + R_2C_2) \ln\left(1 + \frac{V_{cc}}{V}\right)$$

$$T = 2RC \ln\left(1 + \frac{V_{cc}}{V}\right) \quad (\because R_1 = R_2 = R \text{ and } C_1 = C_2 = C)$$

(or)

frequency, $\boxed{f = \frac{1}{2RC \ln\left(1 + \frac{V_{cc}}{V}\right)}}$

By varying V, the frequency f can be varied and hence Astable multivibrator is referred as voltage-to-frequency converte

www.Jntufastupdates.com Scanned with CamScanner