UNIT – III

22/08/2017

MULTIVIBRATORS

Multivibrators are basically regenerative circuits comprising of two cross coupled active devices like Bipolar junction Transistors, the output states of a multivibrator depend upon the nature of coupling between the active elements involved.

classification:

Multivibrators (Multis) are broadly classified into three categories based upon their output states.

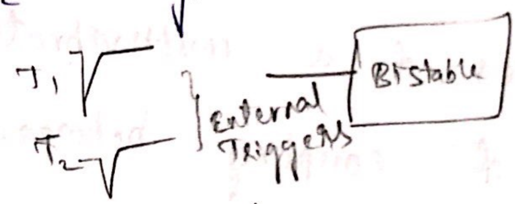
(1) Bistable Multivibrators

(2) Monostable Multivibrators.

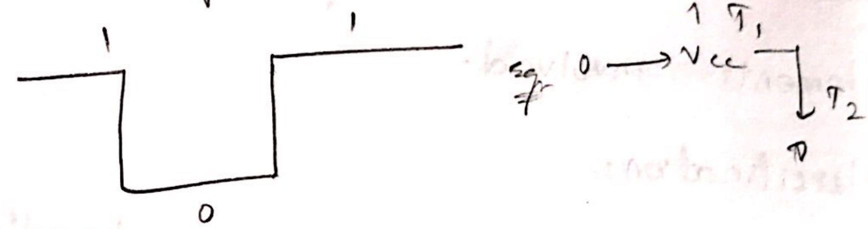
(3) Astable Multivibrators

(1) Bistable Multivibrator:

A Bistable Multi has two stable output states. It can remain indefinitely in any one of the two stable states and it can be induced to make an abrupt transistion to the under stable state by means of suitable ~~external~~ external excitation. It will remain indefinitely in the state until it is again induced to switch into the original stable state by external triggering.



Eg:-



Bistable multivibrators are also termed as Binaries or flip flops. ~~A Binary~~ is sometimes referred to as Eclass · Jordan circuit.

(2) Monostable Multivibrator:-

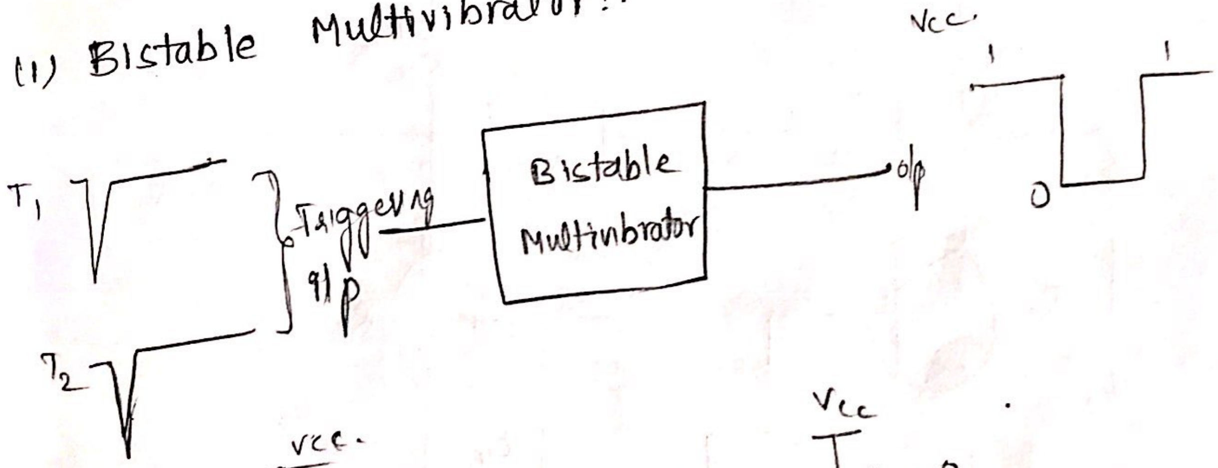
It has one stable state and one quasi state it can remain the stable state indefinitely when a suitable external trigger is applied. the monostable multi switches into the quasi stable state it remains in the quasi stable state for a short duration and switches back into the stable state without any external Triggering.

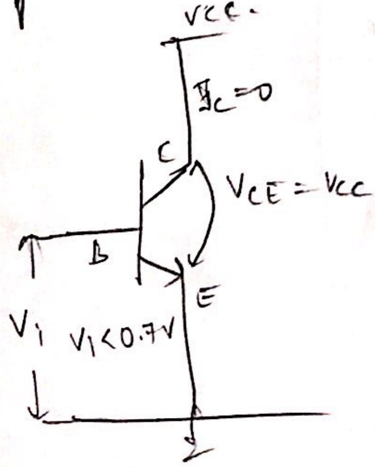
A monostable multi is also called one-shot.

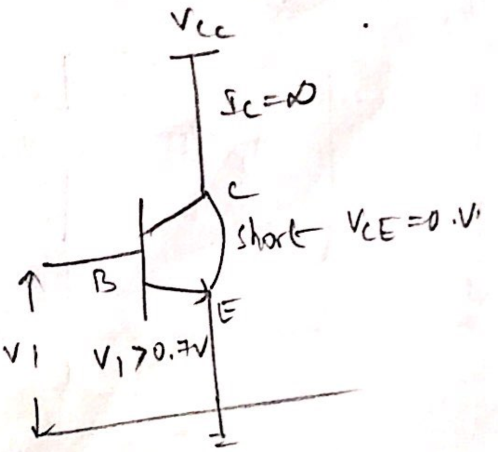
(3) Astable Multibrator:

It has two output states. Both of which are quasi stable. The astable multi cannot remain indefinitely in any of these two states and it keeps on switching between the two states.

(1) Bistable Multivibrator:.

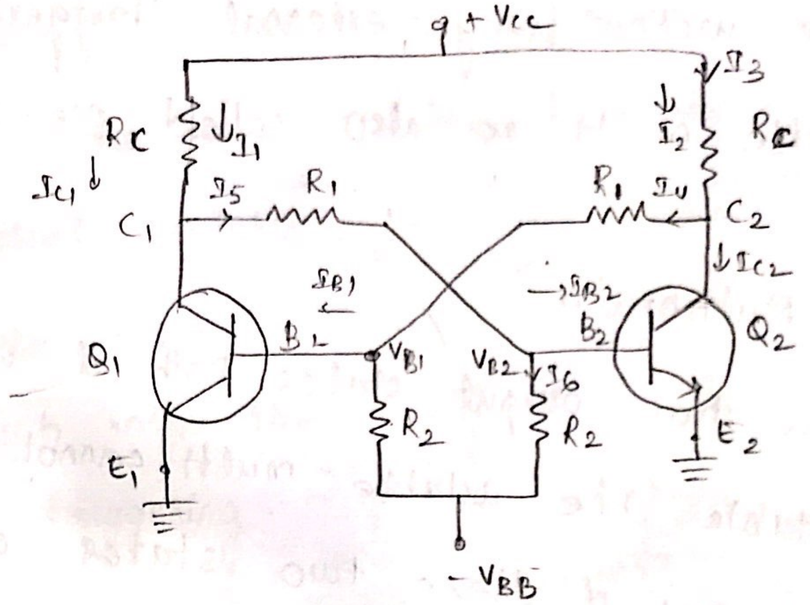






$$0 \xrightarrow[\text{flip}]{T_1} V_{cc} \xrightarrow[\text{flop}]{T_2} 0$$

Fixed Bias Bistable Multivibrator :- 23/08/2017



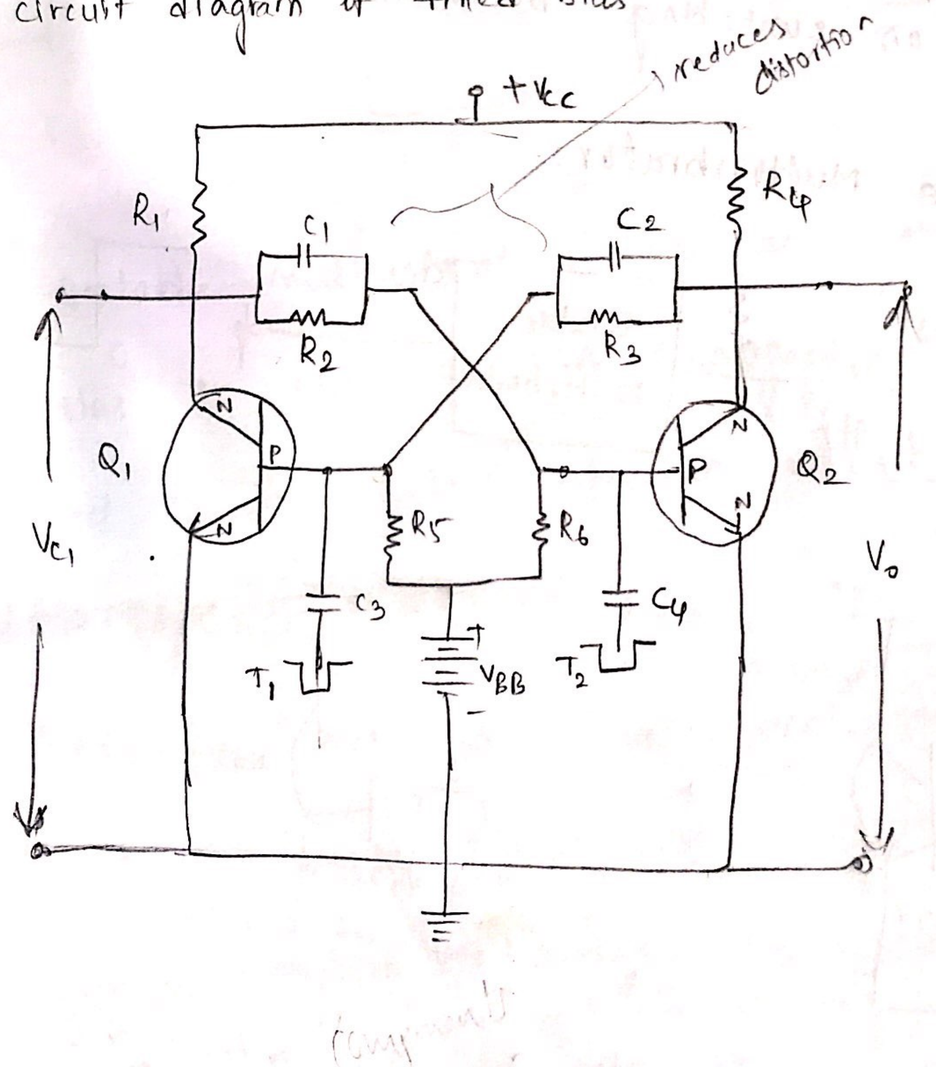
$V_{C1} = 0.2V$ I_{C1}

$V_{C2} =$ I_{C2}

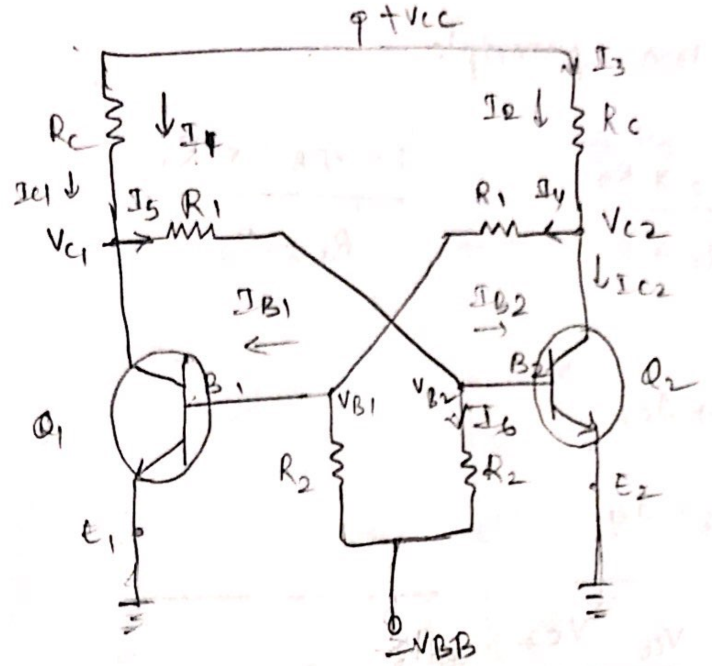
$V_{B1} = 0.7V$ I_{B1}

$V_{B2} =$ $I_{B2} = 0$

circuit diagram of fixed bias Bistable Multivibrator



Fixed ~~Self~~ Bias Bistable Multivibrator:-



Fixed Bias:-

To find

$I_{C1} = 0\,A$ $\quad$ $I_{B1} = 0\,A$

V_{C1} $\quad$ V_{B1}

I_{C2} $\quad$ I_{B2}

$\underbrace{V_{C2} = 0.2V \quad V_{B2} = 0.7V}_{\text{saturation voltages of silicon.}}$

Consider the stable state condition if Q_1 is ON and Q_2 is OFF.

to find V_{C1} :

Using superposition theorem

$$V_{C1} = \underset{(Q_2 \text{ is short})}{\frac{V_{CC} \times R_1}{R_1 + R_C}} + \underset{(Q_1 \text{ is short})}{\frac{V_{B2} \times R_C}{R_1 + R_C}}$$

To find V_{B1} :-

Using superposition principle

$$V_{B1} = \frac{V_{C2} \times R_2}{R_1 + R_2} + \frac{(-V_{BB}) \times R_1}{R_1 + R_2}$$

from

$$I_3 = I_4 + I_{C2}$$

$$I_{C2} = I_3 - I_4$$

$$I_3 = \frac{V_{CC} - V_{C2}}{R_C}$$

$$I_4 = \frac{V_{C2} - V_{B1}}{R_1}$$

$$\boxed{I_{C2} = I_3 - I_4}$$

→ $I_5 = I_6 + I_{B2}$

$$\boxed{I_{B2} = I_5 - I_6}$$

$$I_5 = \frac{V_{C1} - V_{B2}}{R_1}$$

$$I_6 = \frac{V_{B2} + V_{B3}}{R_2}$$

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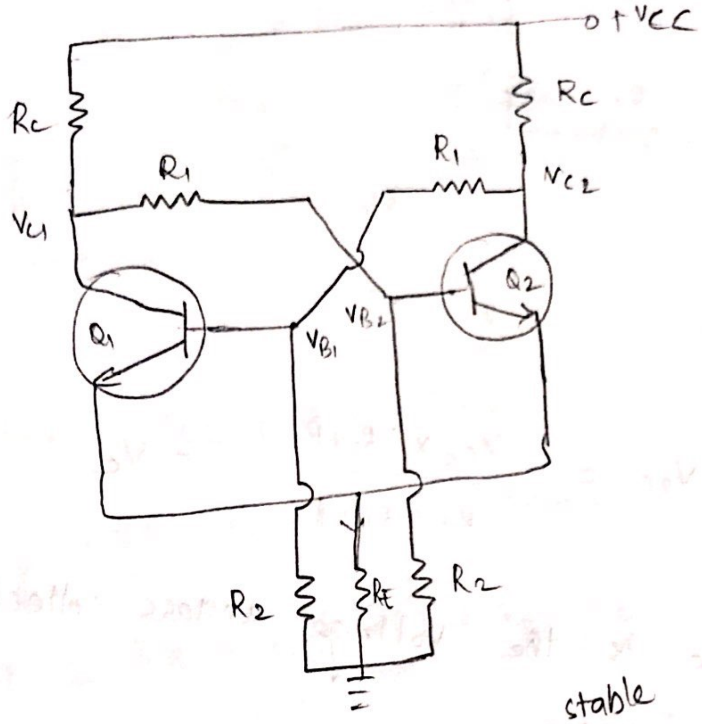
Self Bias Bistable Multivibrator 24/08/2017



Bistable Multivibrator has 2 stable states.

1st stable state Q_2 - ON , Q_1 - OFF

2nd stable state Q_2 - OFF , Q_1 - ON

Now, consider Q_2 - ON , Q_1 - OFF.

To find

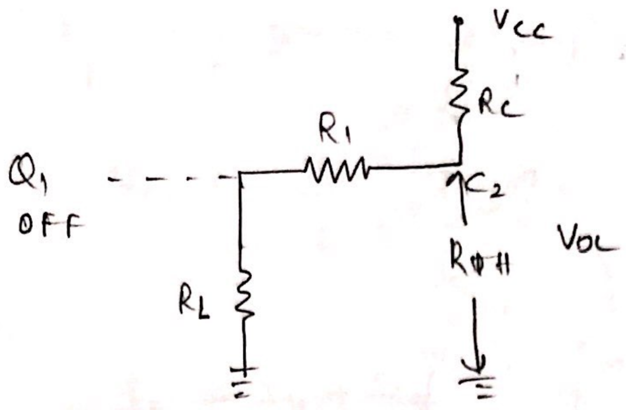
V_{C2} V_{B2} I_{C2} I_{B2}

V_{C1} V_{B1} $I_{C1} = 0A$ $I_{B1} = 0A$ ($\because Q_2$ is O

for $V_{C2} = V_{CE}(sat) + V_E$

$V_{B2} = V_{BE}(sat) + V_E$

Thevinin's Equivalent of Q_2 across collector to ground:



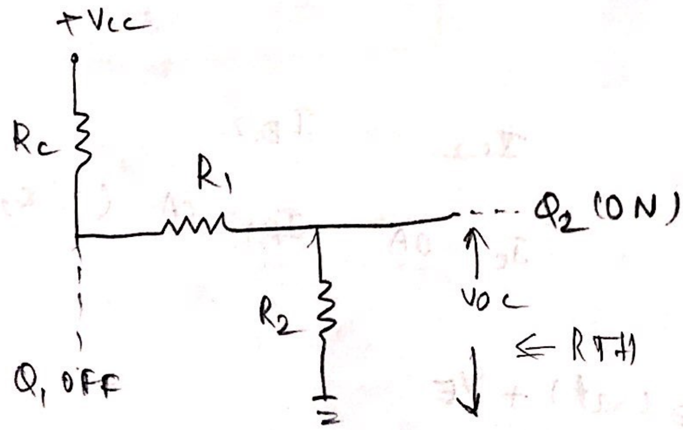
$$\therefore V_{oc} = \frac{V_{cc} \times (R_1+R_2)}{R_c + R_1 + R_2} = V_c$$

where V_c is the voltage across collector terminal Q_2 to ground

and $R_{TH} = R_c \parallel (R_1+R_2)$

$= R_c$ (collector Resistor)

Thevinin equivalent circuit across base to ground:

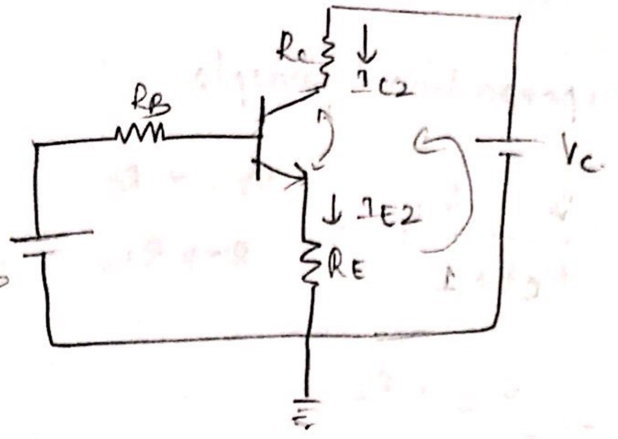


$$V_{oc} = \frac{V_{cc} \times R_2}{R_c + R_1 + R_2} = V_B$$

$R_{TH} = (R_c + R_1) \parallel R_2$

$= R_B$ (Base resistance)

Equivalent circuit for Q_2 ON :-



where $I_{E2} = I_{C2} + I_{B2}$

Applying KVL to above circuit

$$\Rightarrow V_B = I_{B2} \cdot R_B + V_{BE}(sat) + I_{E2} \cdot R_E.$$

$$V_B = I_{B2} \cdot R_B + \underbrace{V_{BE}(sat)}_{0.7\,V} + (I_{B2} + I_{C2})\, R_E \rightarrow (1)$$

$$\Rightarrow V_C = I_{C2} \cdot R_C + V_{CE}(sat) + I_{E2}\, R_E$$

$$V_C = I_{C2} \cdot R_C + \underbrace{V_{CE}(sat)}_{0.2\,V} + (I_{B2} + I_{C2})\, R_E \rightarrow (2)$$

Solving eqn (1) & eqn (2), we get I_{C2} and I_{B2}

$\therefore$ we know, $I_{E2} = I_{B2} + I_{C2}$

$$V_E = I_{E2} \cdot R_E$$

Hence $V_{C2} = V_{CE}(sat) + V_E$

$$V_{B2} = V_{BE}(sat) + V_E.$$

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To find V_{C1}, V_{B1}

By Applying superposition principle

we get $V_{C1} = \dfrac{V_{CC} \times R_1}{R_C + R_1} + \dfrac{V_{B2} \times R_C}{R_C + R_1}$

& $V_{B1} = \dfrac{V_{C2} \times R_2}{R_1 + R_2}$

Types of Triggering:- 29/08/2017

Triggering is of two types.

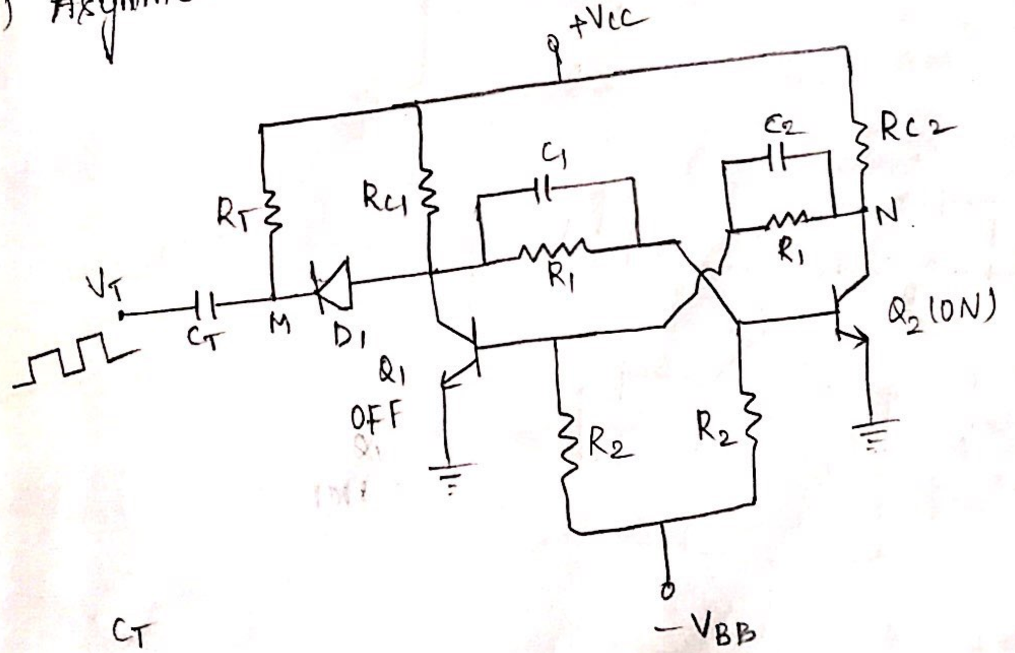
(1) Unsymmetrical (or) Asymmetrical Triggering

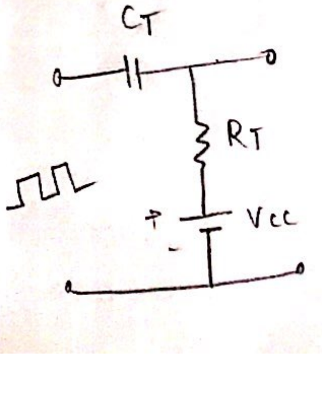
(2) Symmetrical Triggering

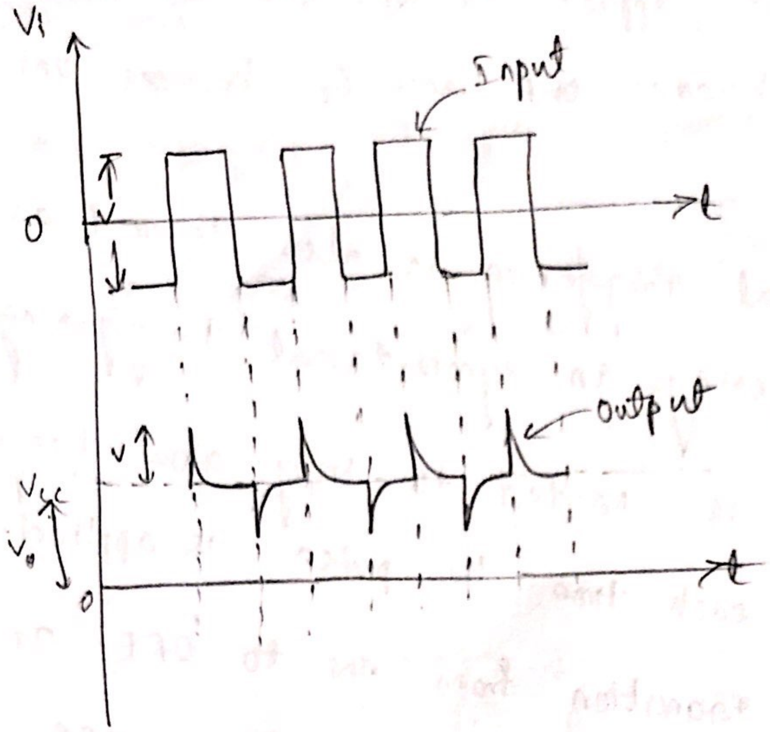
In unsymmetrical Triggering. two triggering pulses from two seperate sources are needed to change the states of the Binary. when a triggering pulse from a source is applied to one of the transistors say Q_2 which is ON, Q_2 becomes OFF and Q_1 which was OFF will become ON. Q_2 continues to be OFF and Q_1 continues to be 'ON'. untill another triggering pulse from another source is applied to Q_1. with the result that Q_1 again becomes OFF and Q_2 becomes 'ON'.

⇒ Asymmetrical Triggering is also termed as Set Reset Triggering. In symmetrical triggering only one Triggering pulse is needed to bring about change of state and each time the pulse is applied. There results a Transition from ON to 'OFF' or from 'OFF' to 'ON'. Thus from a single source triggering can be effected in both directions.

(1) Asymmetrical or Unsymmetrical Triggering :-







$C_1 = C_2 = \dfrac{1}{2.3\, f_{max} (R_1 \| R_2)}$

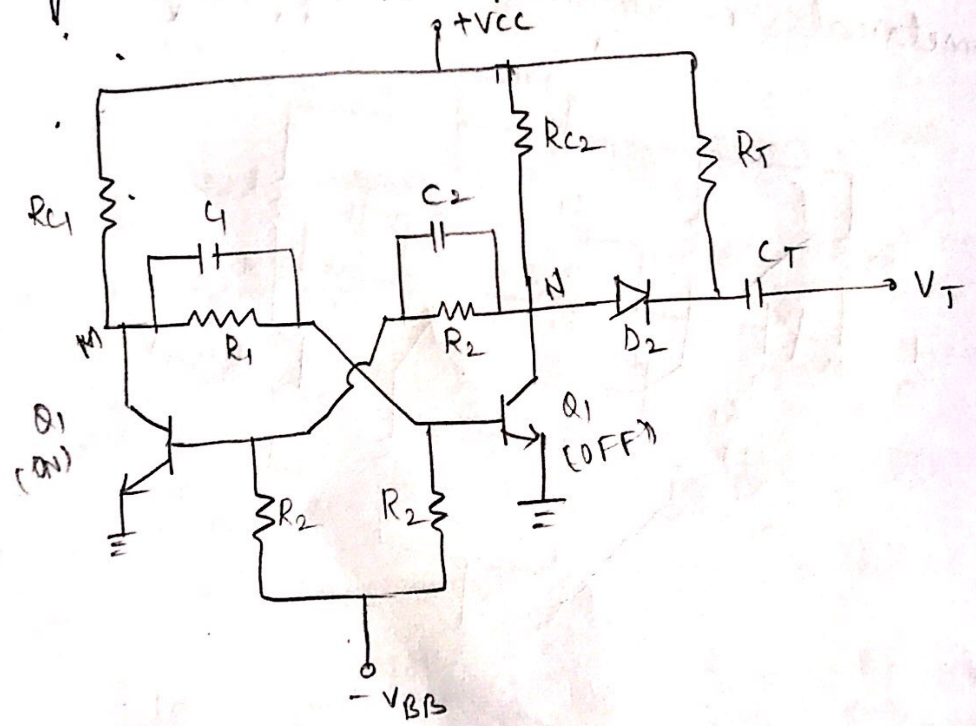
But $R_1 \| R_2 = \dfrac{R_1 R_2}{R_1 + R_2}$

$= \dfrac{R_1 + R_2}{2.3 \cdot f_{max} R_1 R_2}$

where f_{max} = maximum triggering frequency

Asymmetrical Triggering

~~(2) Symmetrical~~ Triggering:



The figure shows a fixed Bias Binary along with the triggering circuit comparising of resistor R_T, capacitor C_T and diode D_1, C_1 & C_2 are comutating capacitors. C_T & R_T together constitute a differentiator circuit and when a pulse is applied as input to such a circuit the output is in the form of spikes as shown in the figure. These voltage spikes are alternately positive & Negative w.r.t V_{cc}. It is seen that the diode D_1 can transmit only negative spikes. A Negative spike appearing at 'M' is transmitted to the commutating capacitor C_1 and it appears at the base of the ON transistor Q_2. As a result, the base of Q_2 ~~results~~ goes negative and Q_2 becomes OFF. As already studied that when Q_2 becomes OFF, Q_1 becomes 'ON'. In order to restore with the binary to the original state i.e, Q_1 OFF and Q_2 ON. A similar triggering arrangement is provided at the collector of

Q2. If continuous triggering of the binary when both directione is required the triggering arrangement is switched between the points 'M' and 'N' alternatively. Asymmetrical Binary triggering requires two triggering pulses from two seperate sources.

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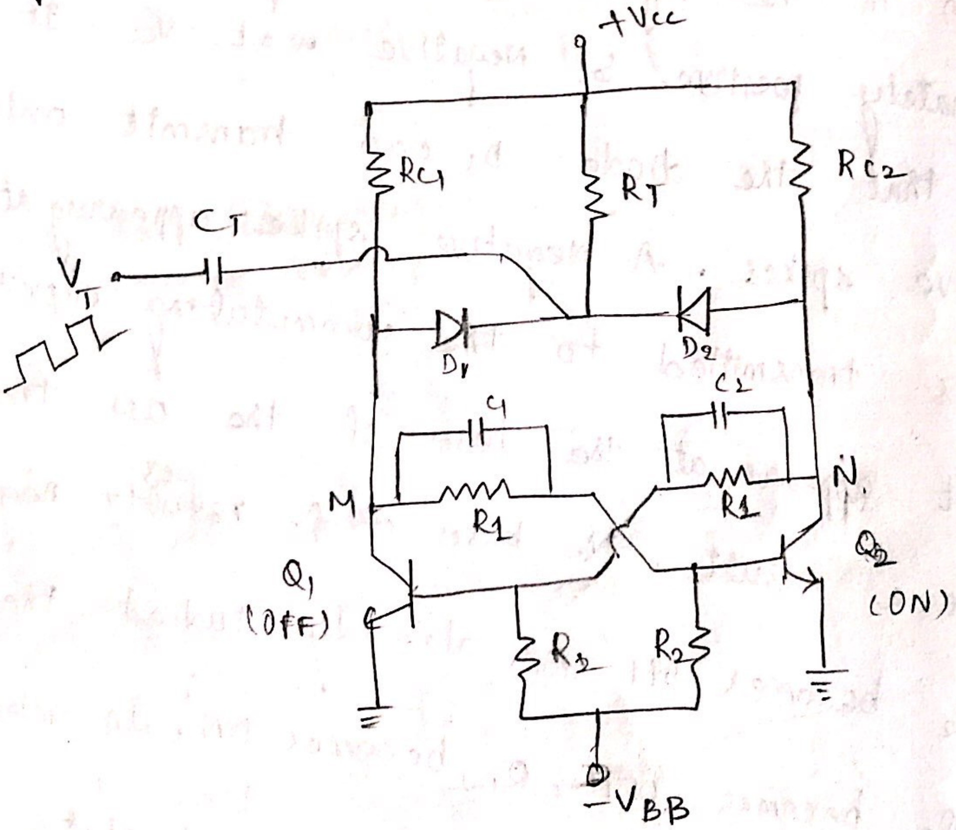
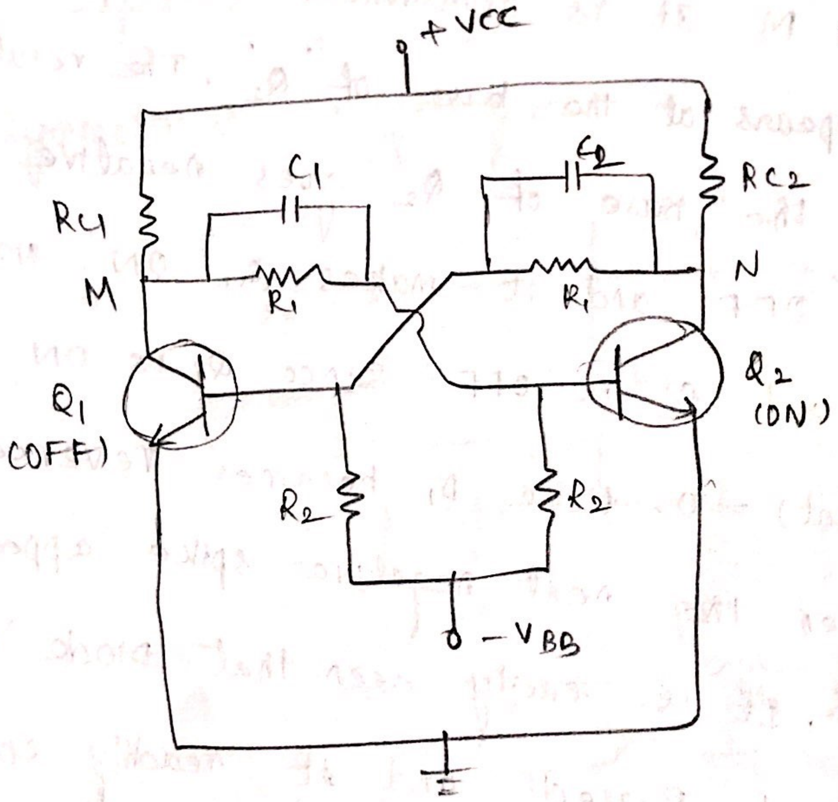
(2) Symmetrical Triggering :-



In symmetrical Triggering, triggering in either direction is effected by means of pulses obtained from the same source. Let Q_2 is ON, and Q_1 is OFF. Since Q_2 is ON ie, in saturation $V_N = V_{CE}(sat) = 0$. Hence the supply voltage V_{CC} which is positive. reverse biases diode D_2.

when a Negative Triggering pulse appears at point 'p' Diode D_1 gets forward biased and readily conducts. Hence the negative spikes gets applied at 'M'. It is transmitted to capacitor C_1 and it appears at the base of 'Q_2'. The result of it is that the base of Q_2 goes negative & Q_2 becomes 'OFF'. and it makes Q_1 'ON'. Now Q_1 is ON and Q_2 is OFF. Since Q_1 is ON then $V_M = V_{CE}(sat) = 0$. Hence D_1 becomes reverse biased when the next negative spike appears at point 'p'. It is easily seen that Diode 'D_2' becomes forward Biased and it readily conducts Hence the negative spike gets applied at point 'N'. It is transmitted through capacitor C_2 and appears at the base of 'Q_1'. The base of Q_1 goes negative with the result that Q_1 becomes 'OFF' and it makes Q_2 'ON'. Thus width pulses obtained from the same triggering source, triggering of the Binary in either Direction is effected for this reason this type of triggering is termed as symmetrical Triggering.

Commutating Capacitors :-



C_1, C_2 are commutating capacitors

In order to increase the switching speed of multivibrators there is a need to shunt the coupling Resistors R_1, R_1 by suitable capacitors C_1 and C_2. These capacitors are also teamed as

Speed Up capacitors or Transpose capacitors :

Let Q_2 be ON & Q_1 be OFF. In order to change the state of the Binary a negative spike voltage is applied to the collector of the OFF transistor Q_1 and this appears at the Base of the ON transistor Q_2. Since the base of Q_2 goes negative, the potential of its collector terminal 'N' rapidly rises. This increase of voltage at the collector of Q_2 must be Quickly transmitted to the Base of Q_1. So as to change its state from OFF to ON. as quickly as possible. This is achieved by providing a suitable capacitor 'C_2' across R_1. Resistors R_1, R_2 & capacitor C_1 and C_2 together constitute a perfectly compensated attenuator and a full voltage rise at 'N' would be immediately transmitted to the base of 'Q_1' and Q_1 would be 'ON' fastly. capacitor C_2 must be properly designed. since it should not be too large or too small. The main feature of the commutative capacitor is that they reduce the transistion time and increase the switching speed. Hence the name speed up capacitors.

The relationship in the design of speed of capacitors is

$$C_1 = C_2 = \frac{R_1 + R_2}{2.3\, R_1 R_2\, f_{max}}$$

(2) Monostable Multivibrator :-

A Monostable Multivibrator has only one stable state. The other state is quasi stable (Temporary state). The Monostable Multivibrator is in stable state unless and untill an external pulse is applied.

When an external triggering pulse is applied it switches from the stable to quasi stable state. It remains in the quasi stable state for a short duration and automatically switch back to its original stable state without any triggering pulse.

The output of the Monostable multivibrator while it remains in the quasi stable state is a pulse of duration T. whose value depends upon the circuit components. Hence the monostable multivibrator is called a pulse Generator. The Monostable multivibrator is also reffered to as one shot or univibrator. Since only one Triggering signal pulse is required to come back to the original stable state.

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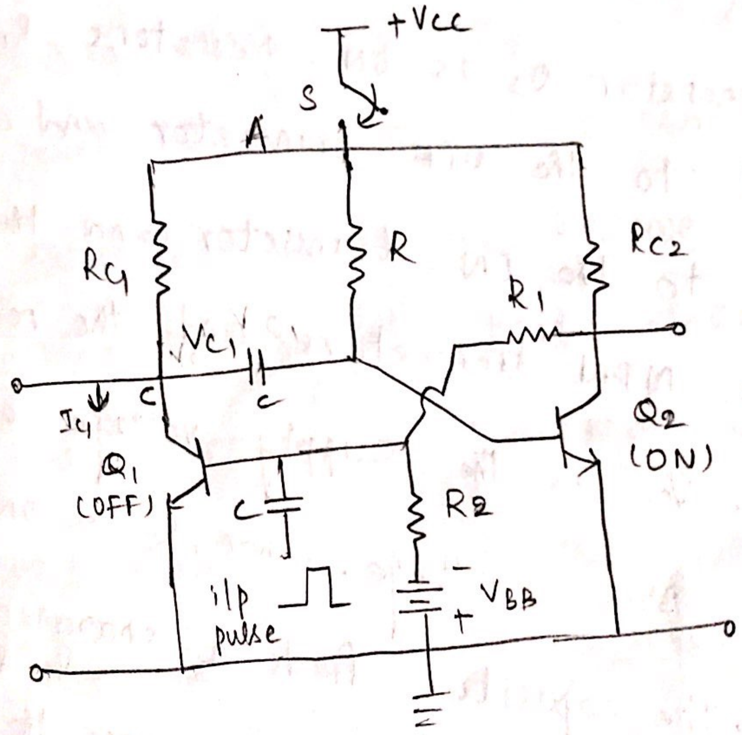
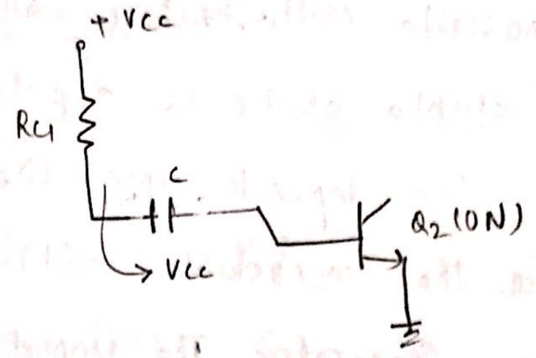
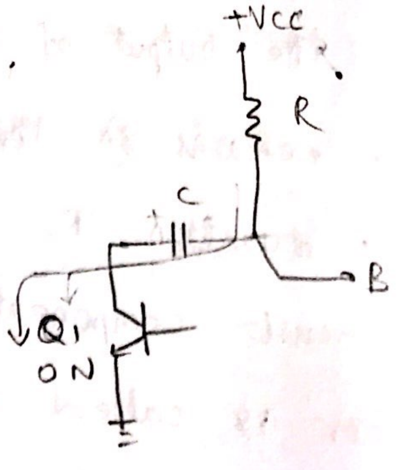


Monostable Multivibrator circuit.



fig(a)



fig(b)

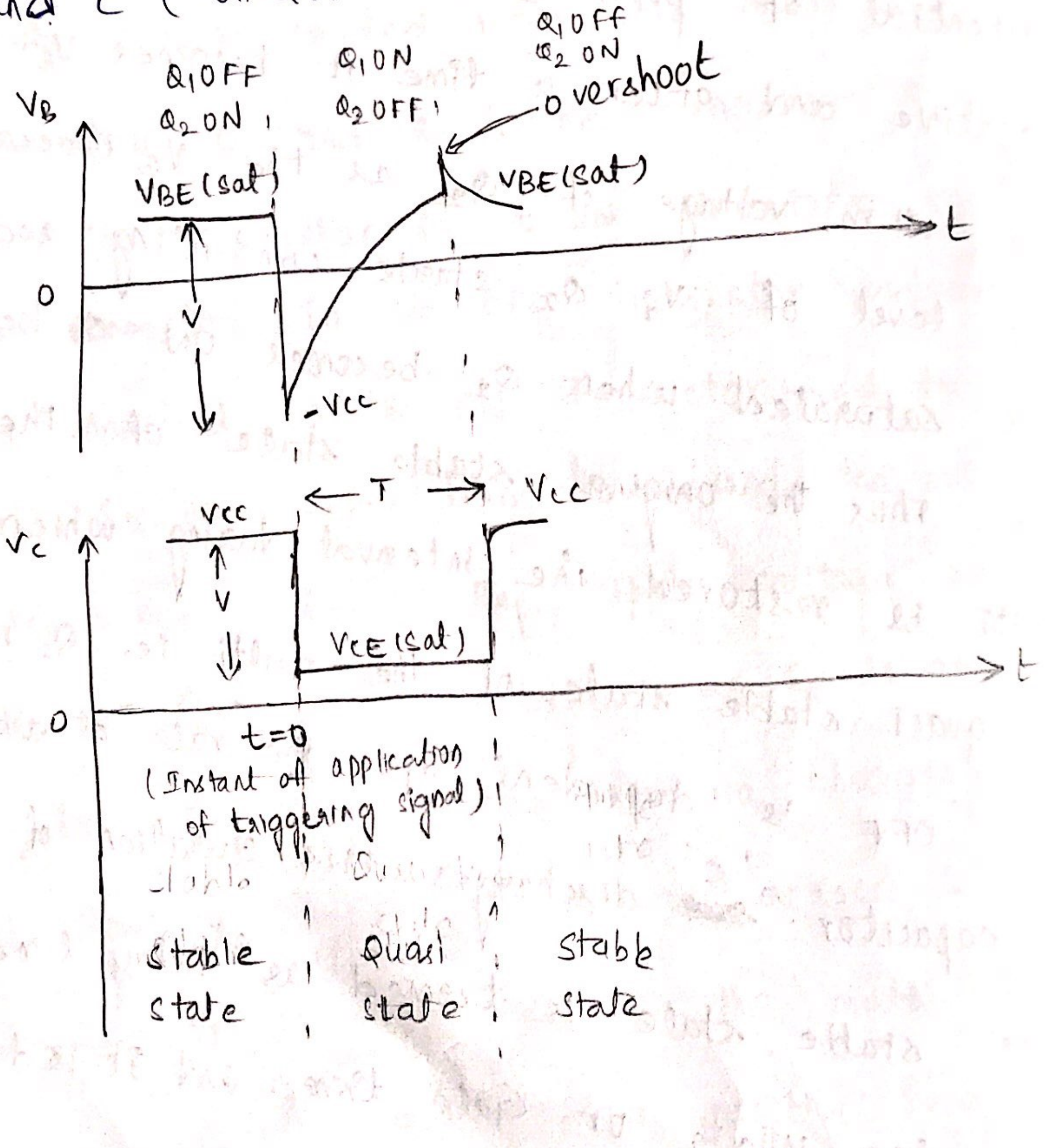
Principle of operation :

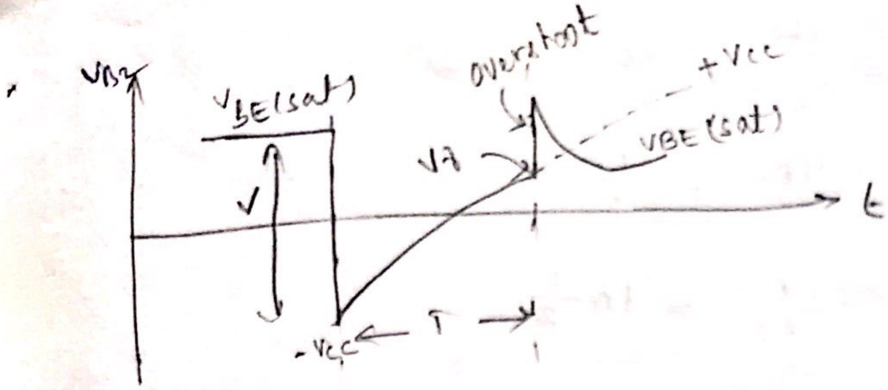
The collector coupled monostable multi of two transistors Q_1 and Q_2, the transistor Q_1 is OFF and the transistor Q_2 is ON. Resistors R_1 & R_2 are connected to the OFF transistor and capacitor is connected to the ON transistor and the Q_1 and Q_2. are NPN transistors and the resistors $R_{C1} = R_{C2}$. Vcc is the supply voltage and VBB is the Bias voltage. when Q_2 is ON and Q_1 is OFF. The capacitor finds a charging path as shown in fig(a). The voltage across the capacitor is Vcc. In the stable state of the multi Q_2 is ON and Q_1 is OFF. If a positive triggering pulse is applied to the base of Q_1 which makes the transistor Q_1 ON making Base to Emitter of Q_1 forward biased. Once the transistor Q_1 is ~~small~~ ON. Automatically the transistor Q_2 goes to OFF state. This state is only a quasi stable state. (Temporary stable state). when Q_1 ON and Q_2 OFF the capacitor 'C' finds a discharging path as shown in fig b. As the capacitor discharges the potential of point B becomes less and less negative and after a time it becomes $V_B = V_\gamma$ the cutt in voltage of Q_2 as the V_B crosses the level of V_γ. Q_2 starts conducting and gets saturated. when Q_2 becomes ON Q_1 becomes OFF. Thus the original stable state of the multi is restored. The interval during which the quasi stable state of the multi ie, Q_2 remains 'OFF' is dependent upon the rate at which the capacitor 'C' discharges. This duration of quasi stable state is termed as Delay time or pulse width or Gate time. and it is denoted as 'T'.

No.

If a negative Triggering pulse is applied to the collector of Q_1. It is transmitted to the base of Q_2 to the capacitor and hence makes the base of Q_2 negative and the transistor Q_2 goes OFF and Q_1 becomes ON.

The waveforms of the voltages at points B (base of Q_2) and C (collector of Q_1) are





Expression for Pulse width (T) :- 04/09/2017

Referring to the waveform of fig(c) we have

initial value of V_B at $t=0$

$$V_{in} = -V_{CC}$$

As the capacitor discharges the voltage V_B rises exponentially and would attain the value '$+V_{CC}$'. But at $t=T$, Q_2 becomes ON and as a result V_B takes the value $V_B = V_\gamma$. The cut in voltage of Q_2 which may be taken as zero. Therefore the final value of 'V_B' at $t=\infty$ is $V_{final} = +V_{CC}$ and at $t=T$, $V_B = V_\gamma = 0$. The exponentially increasing voltage V_B is mathematically expressed as

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

at $t=T$ $\quad V_B = +V_{CC} - (V_{CC} - (-V_{CC}))\, e^{-T/RC} = 0 \ (\because V_B = 0)$

$$V_{CC} - (2V_{CC})\, e^{-T/RC} = 0$$

$$2V_{cc}\, e^{-T/RC} = V_{cc}$$

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

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

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

$$\boxed{T = 0.693\, RC.}$$

∴ The Gate width (or) the pulse width is

$$T = 0.693\, RC$$

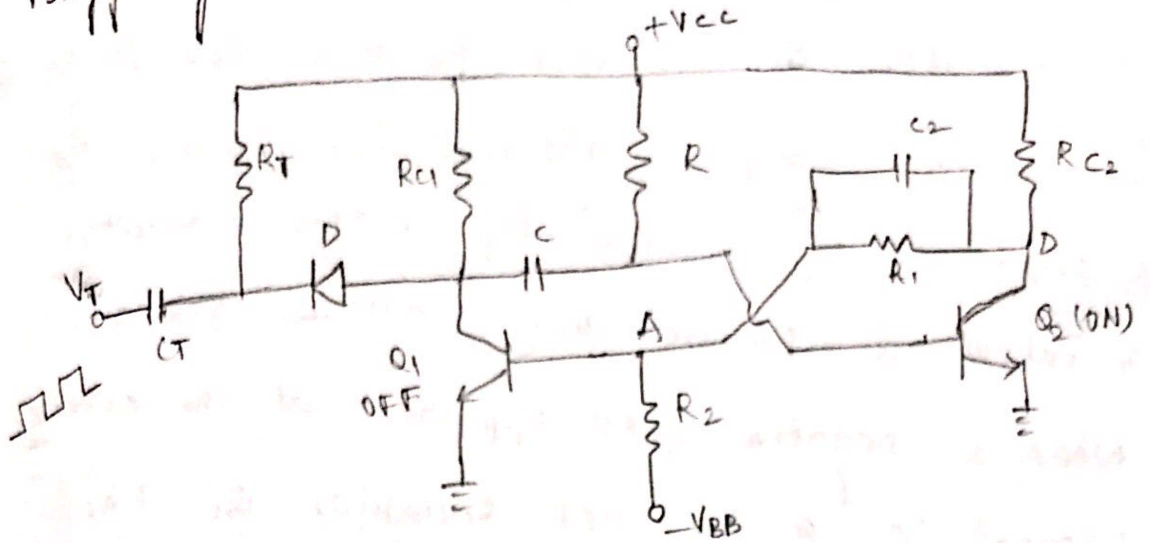
Here the reverse current I_{CBO} of transistor Q_1 has been ignored. If I_{CBO} is taken into consideration the expression for T modifies as

$$T = RC \log_e\left[\frac{2V_{cc} + I_{CBO} \cdot R}{V_{cc} + I_{CBO} \cdot R}\right]$$

If $I_{CBO} = 0$, $T = RC \log_e\left(\frac{2\cancel{V_{cc}}}{\cancel{V_{cc}}}\right)$

$$= 0.693\, RC$$

Triggering of Monostable Multivibrators :-



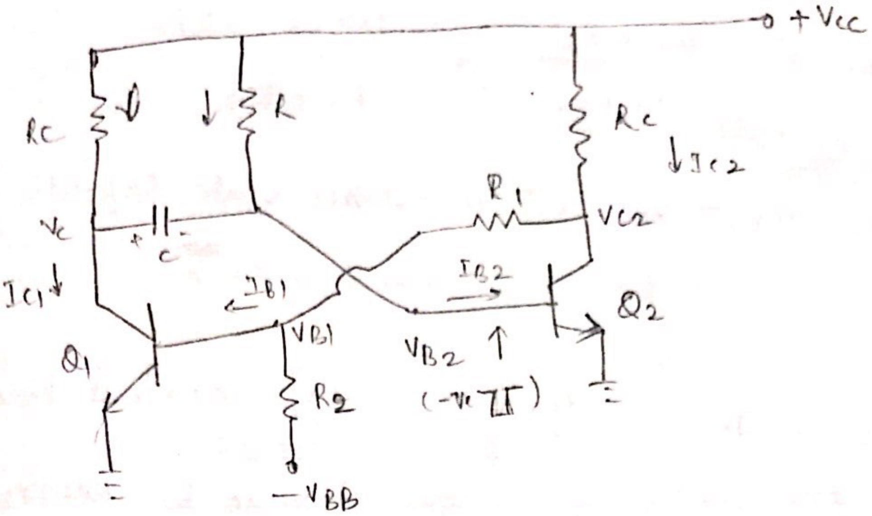
A monostable Multi needs to be triggered
by a suitable signal. Inorder to switch from stable
state to quasi stable state after remaining
the quasi stable state for a time $T = 0.693RC$
it automatically switches back to the original
stable state without any triggering signal applied.
Thus a monostable multi requires only one trigg-
ering signal and unsymmetrical triggering
techniques are adopted for monostable multi's.

From fig, a one shot which employs the
collector triggering mechanism, the triggering pulse
which is in the form of positive & negative
spikes is obtained from a RC differentiator circuit.

and it is applied to the collector of the OFF Transistor Q_1. Resistor R_T and capacitor C_T form a RC High pass differentiator circuit. for a pulse or square wave input. This circuit has an output of positive and negative spikes.

when a negative spike appeared at the collector terminal 'c' of the OFF transistor Q_1, the diode D conducts since it gets Forward Biased, the negative spike gets Transmitted to the capacitor 'c'. and appears at the base of ON Transistor Q_2. The result of it ie, the base of Q_2 goes negative and Q_2 becomes OFF. immediately Q_1 becomes ON. Thus the monostable multi is switched into quasi stable state Thus the symmetrical triggering is not needed for monostable multi vibrator.

Collector - coupled Monostable Multivibrator:- 14/09/2017

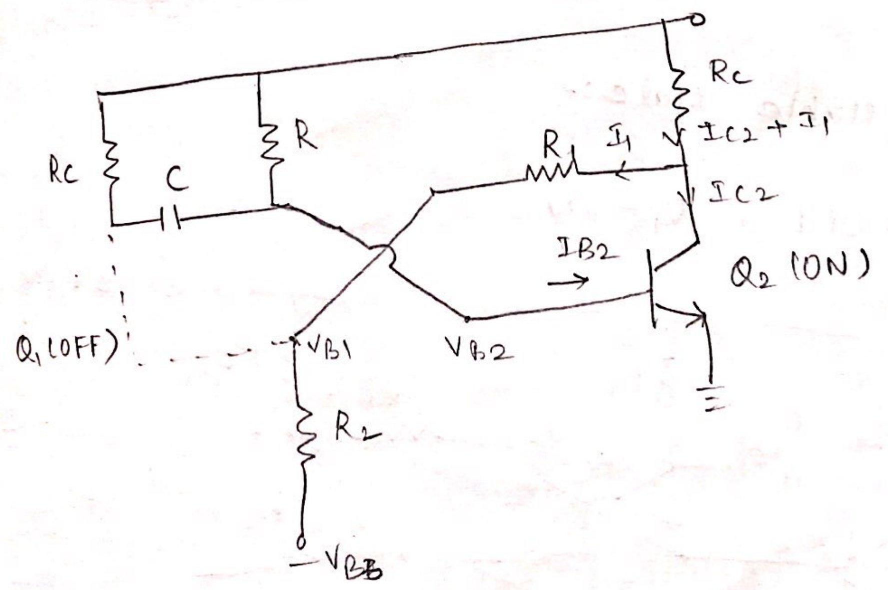


Let Q_2 - ON , Q_1 - OFF (stable state)

$T = 0.69\,RC$

Q_1 - ON , Q_2 - OFF (Quasi stable)

Q_2 - ON , Q_1 - OFF (stable state):



Need $V_{C1} = ?$, $V_{B1} = ?$, $I_{C1} = 0\,A$, $I_{B1} = 0A$

$V_{C2} = V_{CE}(sat)$, $V_{B2} = V_{BE}(sat)$, $I_{C2} = ?$, $I_{B2} = ?$

$\simeq 0.2\,V$ $\qquad \simeq 0.7\,V$

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By Applying superposition ~~Theorem~~ principle

$$V_{B1} = \frac{V_{C2} \times R_2}{R_1 + R_2} + \frac{(-V_{BB}) \times R_1}{R_1 + R_2}$$

and $V_{C1} \cong V_{CC}$ ($\because$ In stable state capacitor holds fixed voltage)

$$I_{C2} + I_1 = \frac{V_{CC} - V_{C2}}{R_C}$$ (ie, current flowing through R_C Resistor)

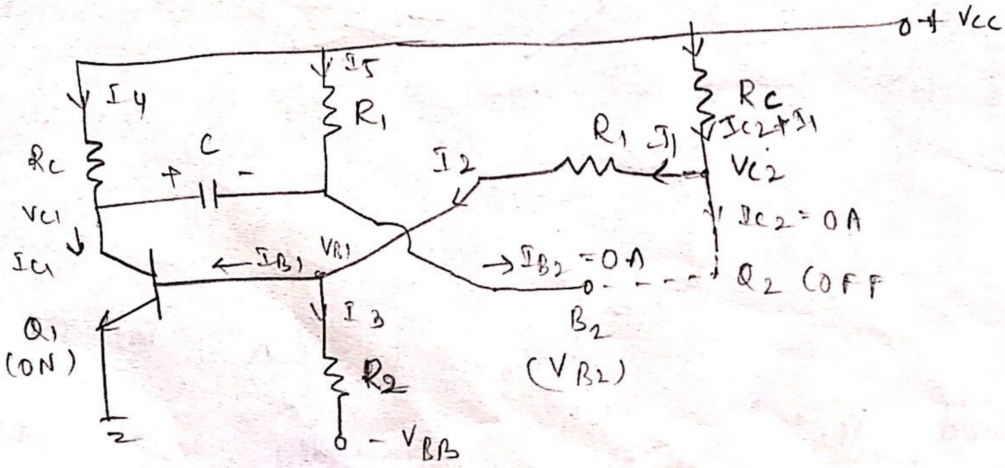
where $I_1 = \frac{V_{C2} - V_{B1}}{R_1}$

Here $I_{C2} = \frac{V_{CC} - V_{C2}}{R_C} - \frac{V_{C2} - V_{B1}}{R_1}$

$$I_{B2} = \frac{V_{CC} - V_{B2}}{R}$$

Quasi- stable state:-

Q_2 = OFF , Q_1 = ON



$V_{C1} = V_{CE(sat)}$ $V_{B1} = V_{BE(sat)}$ $I_{C1} = ?$ $I_{B1} = ?$

V_{C2} V_{B2} $I_{C2} = 0A$ $I_{B2} = 0A$

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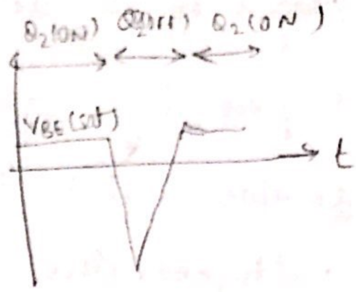
$$I_2 = \frac{V_{CC} - V_{B1}}{R_C + R_1} \quad , \quad I_3 = \frac{V_{B1} - (-V_{BB})}{R_2}$$



$$\therefore I_{B1} = I_2 - I_3$$

$$V_{C2} = V_{CC} - I_2 R_C$$

$$V_{B2} = V_{BE}(sat) - (V_{CC} - V_{BE}(sat))$$

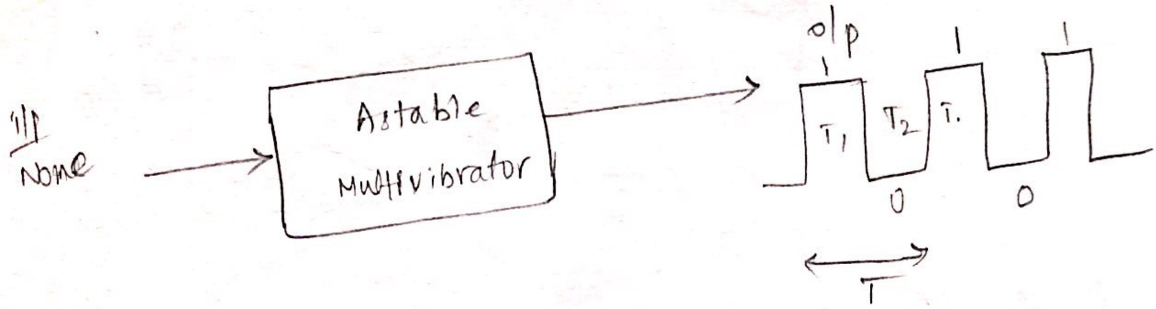
$$\Rightarrow I_{C1} = I_4' + I_5$$

where, $I_4 = \frac{V_{CC} - V_{C1}}{R_C}$, $I_5 = \frac{V_{CC} - V_{B2}}{R}$

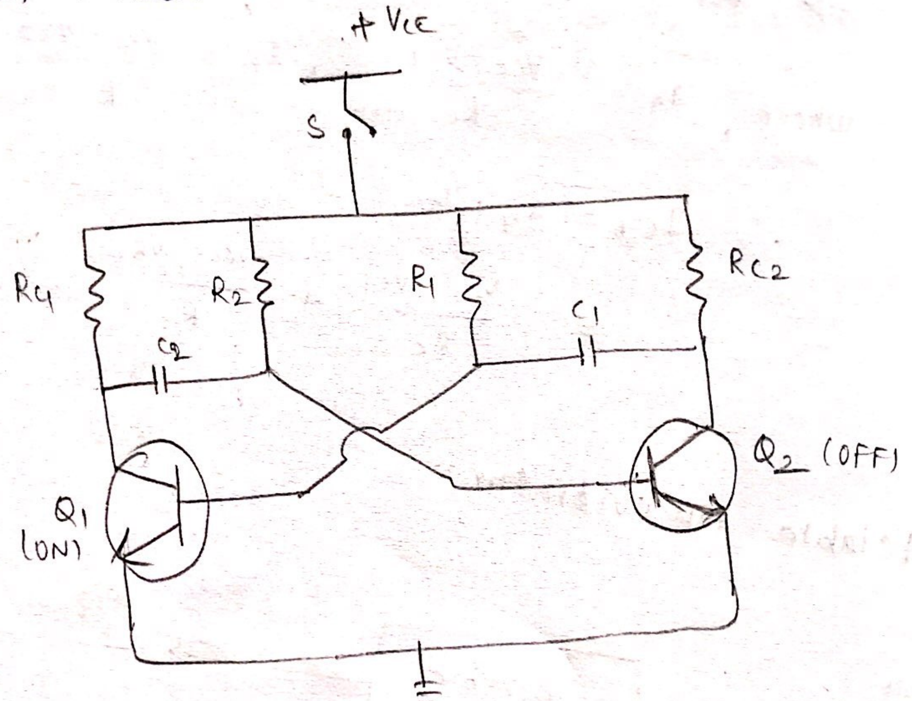
$$\therefore I_{C1} = I_4 + I_5$$

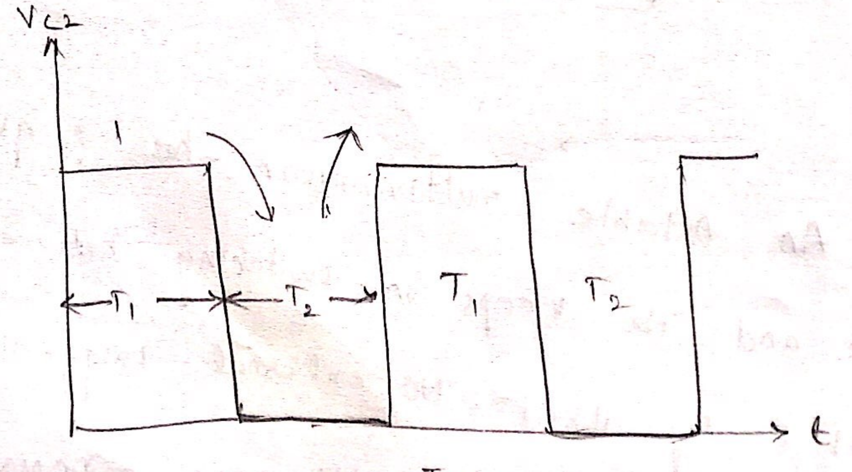
$$= \frac{V_{CC} - V_{C1}}{R_C} + \frac{V_{CC} - V_{B2}}{R}$$

Astable Multivibrator :-



An Astable multivibrator has 2 quasi stable states and its keeps on switching between these two states by itself. No external triggering signal is needed the astable multi can not remain indefinitely in any of these two states. The two amplifier stages of a astable multi are regeneratively cross coupled by capacitors. The output voltage of an astable multi is a square of period T. The astable multi multigenerative square wave is termed as square wave generator or square wave oscillator or relaxation oscillator



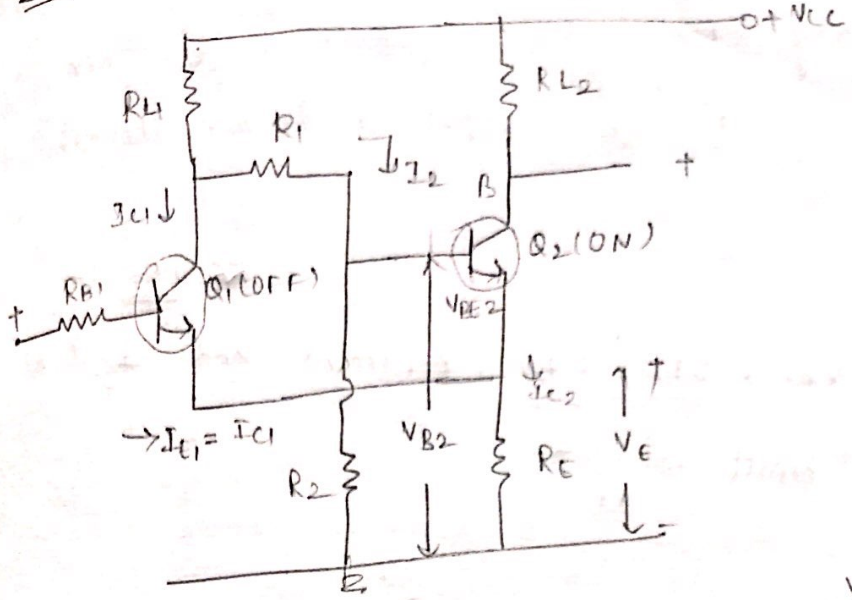


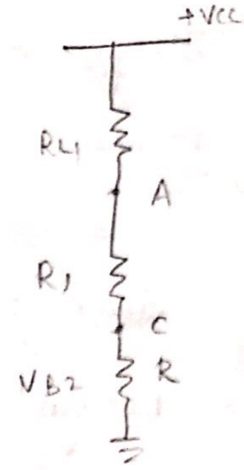
$T = T_1 + T_2$

Schmitt Trigger:-

19/08/2017

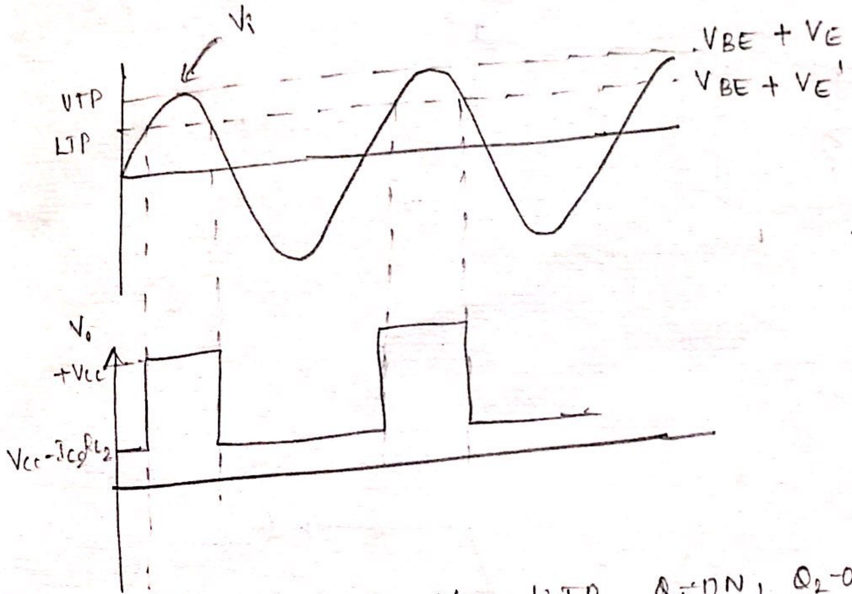
$I_E = \cancel{I_B} + I_C$ neglect





Voltage Divider circuit

$$V_{B2} = \frac{R_2}{R_{L1}+R_1+R_2} V_{cc}$$



$V_i = 0$, Q_1 OFF

+Vcc , Q_2 ON ,

$V_E = I_{C2} R_E$

$UTP = V_{BE1} + V_E$

$V_i > UTP$, Q_1 ON , Q_2 OFF , $I_{C1} R_E = V_E'$, $V_0 = +V_{cc}$

$V_i < LTP$, Q_1 OFF , Q_2 ON $I_{C2} R_E = V_E$,

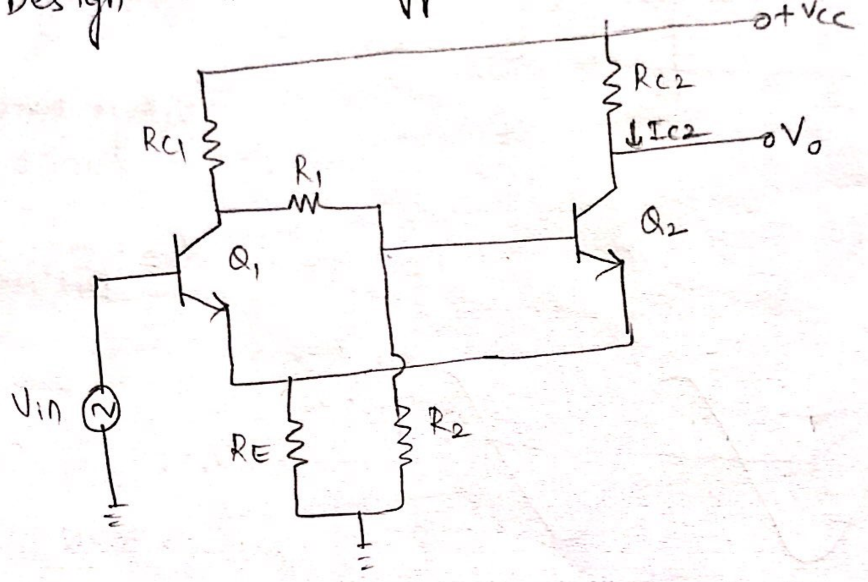
$V_0 = V_{cc} - I_{C2} R_{C2}$

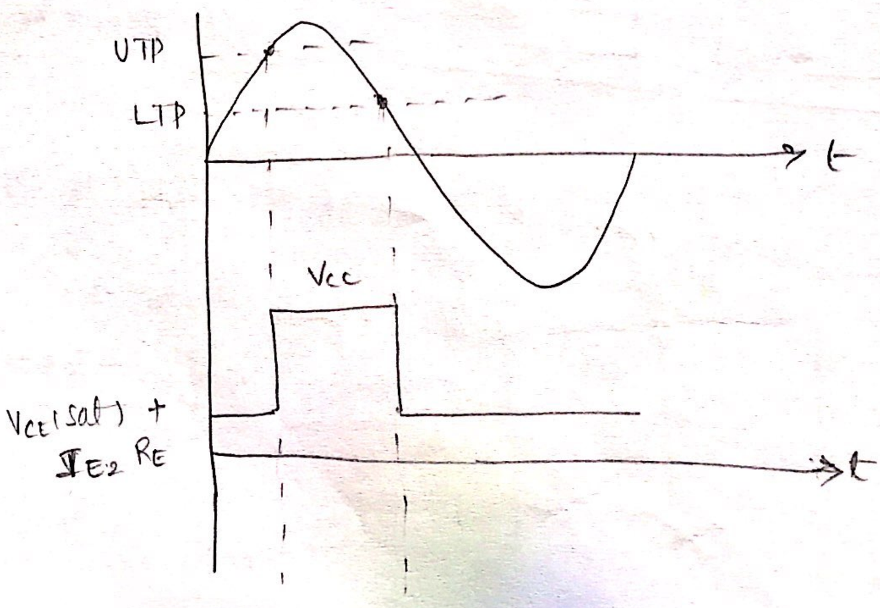
The schmitt Trigger circuit is a comparator circuit which rapidly changes its output voltage when input voltage arrives at the upper or lower threshold levels.

22/09/2017

Given : V_{cc}, UTP, LTP, $h_{fe(min)}$ and $I_{c(on)}$

Design Schmitt Trigger :-





1^{st} stable state

Q_2 - ON and Q_1 OFF

2^{nd} stable state

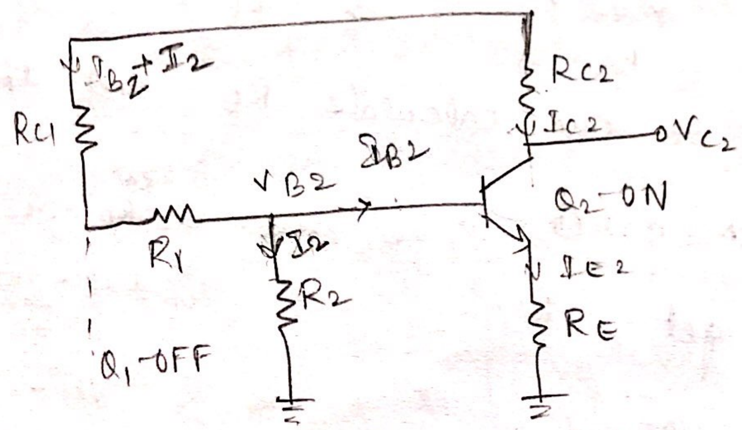
Q_2 - OFF and Q_1 ON

UTP > LTP

If $R_{C1} > R_{C2}$

then $I_{C1} < I_{C2}$ and $I_2 \simeq \frac{I_E}{10}$

1^{st} stable state Q_2 - ON, Q_1 - OFF



$I_{C1} = 0A$

$I_{C(ON)} = I_{C2}$

$$h_{fe(min)} = \frac{I_{C2}}{I_{B2}}$$

$$I_{B2} = \frac{I_{C2}}{h_{fe(min)}}$$

Till UTP Q_2 is ON

UTP = V_{B2}

$$V_{B2} = I_2 R_2$$

$$I_2 = \frac{I_E}{10}$$

$$R_2 = \frac{10 \times V_{B2}}{I_E}$$

from the circuit

$$V_{cc} = I_{C2} R_{C2} + V_{CE(sat)} + I_{E2} R_E \rightarrow (1)$$

$$V_{B2} = V_{BE(sat)} + I_{E2} R_E$$

ie, $UTP = \underbrace{V_{BE(sat)}}_{\simeq 0.7\,V \text{ for silicon}} + I_{E2} R_E \rightarrow (2)$

$$\Rightarrow R_E = \frac{UTP - V_{BE(sat)}}{I_{E2}}$$

From ~~this~~ (2) we can calculate R_E and then substitute in eqn (1). we will get R_{C2}

ie, $V_{cc} = I_{C2} R_{C2} + V_{CE(sat)} + I_{E2}\left(\frac{UTP - V_{BE(sat)}}{I_{E2}}\right)$

$$R_{C2} = \frac{V_{cc} - UTP + V_{BE(sat)} - V_{CE(sat)}}{I_{C2}}$$

∴ from the figure

$$\boxed{R_{C1} + R_1 = \frac{V_{cc} - V_{B2}}{I_{B2} + I_2}} \rightarrow (3)$$

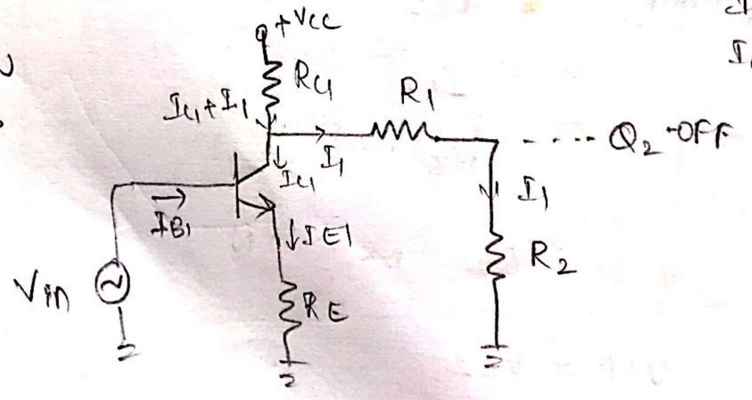
2nd stable state Q_2 - OFF, Q_1 - ON

$I_{B2} = 0A$

$I_{C2} = 0A$

when Q_1 - ON

$V_{in} = LTP$



$$V_{in} = V_{BE}(sat) + I_{E1} R_E$$

$$LTP = \underbrace{V_{BE}(sat)}_{\simeq 0.7V} + I_{E1} R_E$$

$$\therefore I_{E1} = \frac{LTP - V_{BE}(sat)}{R_E}$$

we know, $I_{E1} \simeq I_{C1}$

from the fig.

$$V_{cc} = (I_c + I_1) R_{C1} + I_1 (R_1 + R_2)$$

$$V_{cc} = I_c R_{C1} + I_1 R_{C1} + I_1 R_1 + I_1 R_2$$

$$V_{cc} = I_c R_{C1} + I_1 (R_{C1} + R_1) + I_1 R_2 \rightarrow (4)$$

subn eqn (3) in eqn (4), we will get R_{C1}

$$V_{cc} = I_c R_{C1} + I_1 \left(\frac{V_{cc} - V_{B2}}{I_{B2} + I_2} \right) + I_1 R_2$$

$$= I_c R_{C1} + I_1 \left(\frac{V_{cc} - V_{B2}}{I_{B2} + I_1} + R_2 \right)$$

$$I_c R_{C1} = V_{cc} - I_1 \left(\frac{V_{cc} - V_{B2} + R_2 (I_{B2} + I_1)}{I_{B2} + I_1} \right)$$

$$I_c R_{C1} = \frac{V_{cc}(I_{B2} + I_1) - I_1 (V_{cc} - V_{B2} + R_2 (I_{B2} + I_1))}{I_{B2} + I_1}$$

$$R_{C1} = \frac{V_{cc}(I_{B2} + I_1) - I_1 (V_{cc} - V_{B2} + R_2 I_{B2} + R_2 I_1)}{I_{B2} + I_1}$$

from this R_{C1} subn in eqn (3), we will get R_1

then subn R_1 in eqn (4), we will get R_2.

Time Based Generators :- 4/10/17

→ A Time based generator is an electronic circuit which generates o/p voltage or current that varies linearly with time. Ideally the waveform of the output should be Ramp. The application of such a Ramp voltage is a cathode ray oscilloscope for deflecting the electron beam horizontally across the screen. Since the applied voltage makes the electron beam sweep across the screen. It is termed as sweep Voltage and the circuit generating the sweep voltage is termed as sweep generator. There are two kinds of sweep generator

(a) Voltage sweep Generators and

(b) current sweep Generators.

→ Time based Generators also find applications like RADAR, Television, Time modulation etc

General waveform of the Time based Voltage Generator

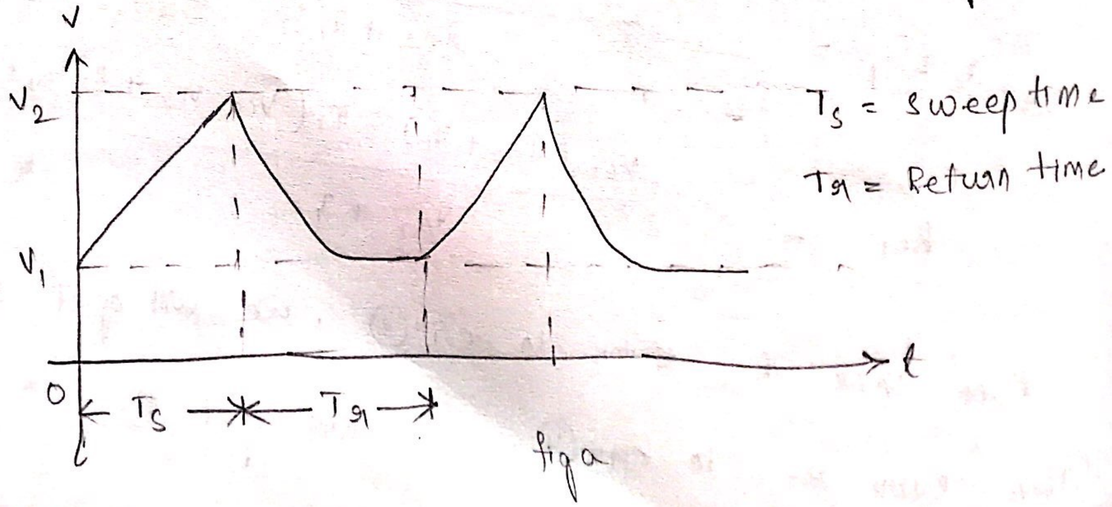


fig a

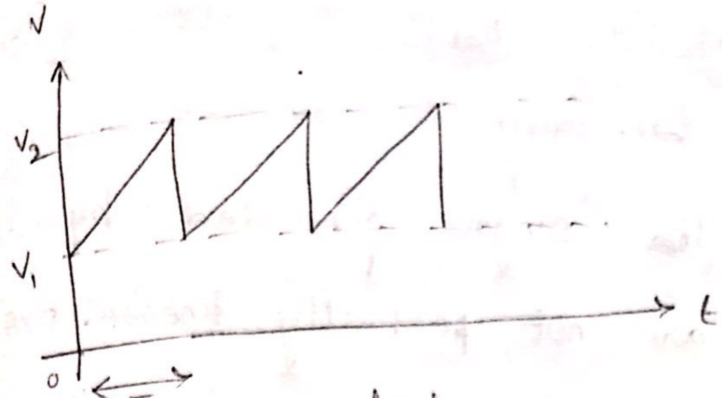


fig b

Sweep time = T_s

Return Time = $T_r = 0$.

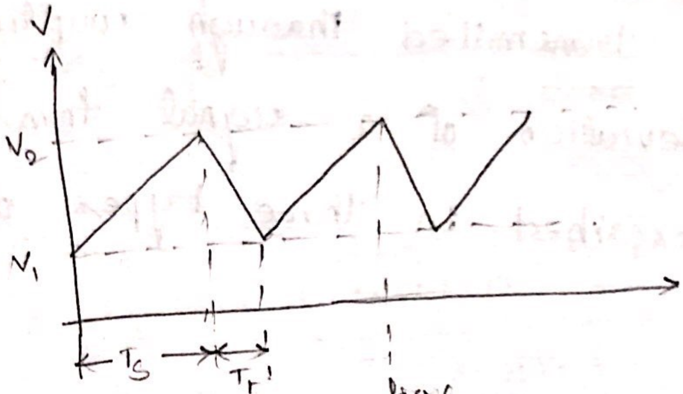


fig c

Triangular wave

where $T_r << T_s$

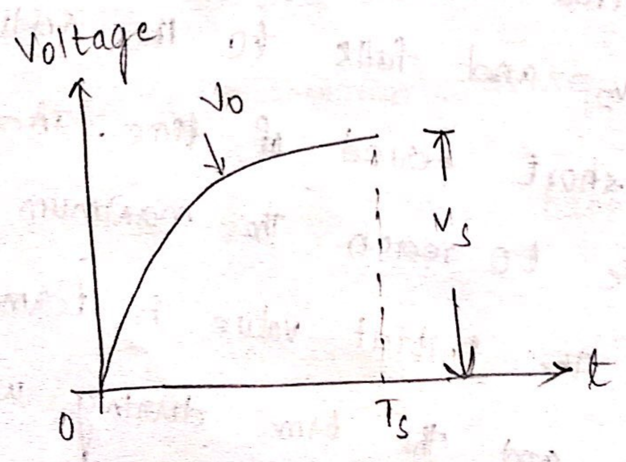
→ A sweep voltage which ideally varies linearly with time has the general waveform shown in the figures. From the fig (a), the voltage starting from an initial value V_1 rises linearly to a peak value V_2 and falls to the initial value V_1 over a short period of time. The time taken by the wave to reach the maximum value starting from the initial value is termed as sweep time and the time during which it ~~becomes~~ returns to the initial value is termed as return time or restoration time or fly back time. Sweep time is denoted as T_s and return time is denoted as T_r.

Deviation from Linearity:-

In practice the singals generated by time base circuits are, not perfectly linear. Even if the signals are linear they suffer ~~distrad~~ distortion when transmitted through coupling Networks. The deviation of a signal from linearity can be described in three types of errors.

(1) sweep Error.
(2) Transmission Error
(3) Displacement Error.

(1) sweep Error (or) sweep speed Error or slope error (or) slope speed Error (e_s) :-



The waveform is not perfectly linear and the slopes of the line at different points are different.

slope error (or) sweep error is defined as the Difference between the initial slope (i.e., at slope at $t=0$) and final slope (i.e., slope at $t=T_s$). It is expressed as fraction of the initial slope. It is denoted as e_s.

$$e_s = \frac{\text{Initial slope} - \text{final slope}}{\text{Initial slope}}$$

(or)

$$e_s = \frac{\left(\frac{dV_s}{dt}\right)_{t=0} - \left(\frac{dV_s}{dt}\right)_{t=T_s}}{\left(\frac{dV_s}{dt}\right)_{t=0}}$$

We know $V_s = V(1 - e^{-t/RC})$

$$\frac{dV_s}{dt} = V(0 - e^{-t/RC})\left(-\frac{1}{RC}\right)$$

$$\frac{dV_s}{dt} = \frac{V}{RC} e^{-t/RC}$$

$$\left(\frac{dV_s}{dt}\right)_{t=0} = \frac{V}{RC} e^{-0} = \frac{V}{RC}$$

$$\left(\frac{dV_s}{dt}\right)_{t=T_s} = \frac{V}{RC} e^{-T_s/RC}$$

$$e_s = \frac{\frac{V}{RC} - \frac{V}{RC} e^{-T_s/RC}}{\frac{V}{RC}}$$

$$= \frac{\frac{V}{RC}\left(1 - e^{-T_s/RC}\right)}{\frac{V}{RC}}$$

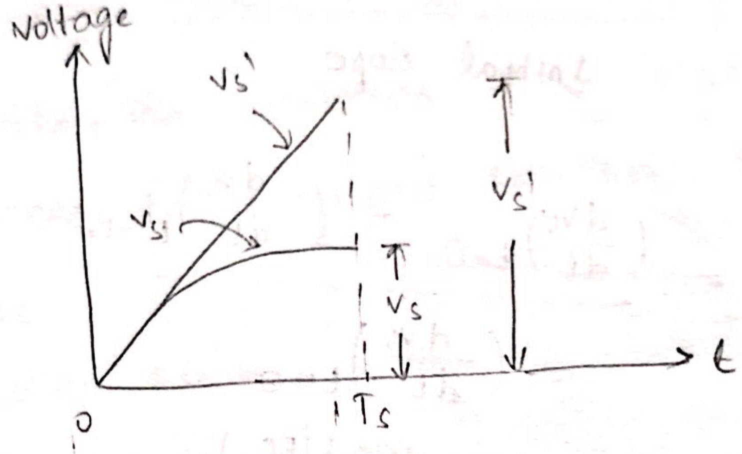
Sweep error $e_s = 1 - e^{-T_s/RC}$

If $T_s << RC$ we have $e^{-T_s/RC} = 1 - \frac{T_s}{RC}$

$$e_s = 1 - \left(1 - \frac{T_s}{RC}\right)$$

$$e_s = \frac{T_s}{RC}$$

Transmission Error :-



when a ramp voltage is transmitted through RC High pass filter it gets distorted as shown in figure. At the end of time T_s, the value of the voltage V_s is less than V_s'. i.e, it has deviated from the linearity. Transmission error is defined as the difference between the input and the output expressed as a fraction of the input.

Let at $t = T_s$, input is V_s' and the output is V_s, Therefore, the transmission error is

$$e_t = \frac{i/p - o/p}{i/p} \quad \text{(OR)}$$

$$e_t = \frac{V_s' - V_s}{V_s'}$$

Since the output voltage V_s is increasing exponentially we have

$$\therefore V_s = V(1 - e^{-t/RC})$$

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

$$= 1 - 1 + \frac{t}{RC} - \frac{(t/RC)^2}{2!}$$ (neglecting higher order terms)

$$= \frac{t}{RC}\left[1 - \frac{t}{2RC}\right]$$

$$V_s = \frac{Vt}{RC}\left(1 - \frac{t}{2RC}\right)$$

At $t = T_s$, $V_s = V_s$

$$V_s = \frac{V T_s}{RC}\left(1 - \frac{T_s}{2RC}\right) \rightarrow (1)$$

The input voltage is a ramp. Hence it can be expressed as

$V_s' = \alpha t$ where α is the slope

slope $= \frac{V}{RC}$ ($\because$ from above eqn)

$$\therefore V_s' = \frac{Vt}{RC}$$

At $t = T_s$, $V_s' = V_s'$

$$\therefore V_s' = \frac{V \cdot T_s}{RC} \rightarrow (2)$$

$$e_t = \frac{\frac{V T_s}{RC} - \frac{V T_s}{RC}\left(1 - \frac{T_s}{2RC}\right)}{\frac{V T_s}{RC}}$$

$$= 1 - 1 + \frac{T_s}{2RC}$$

$$= \frac{T_s}{2RC}$$

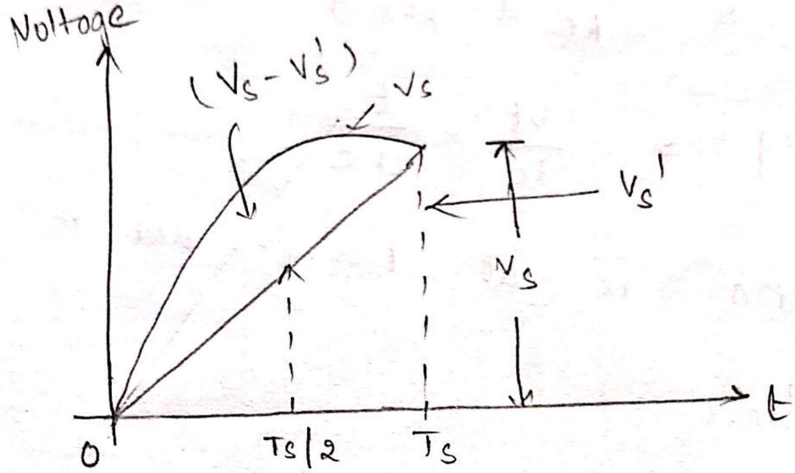
UNIT - III

MULTIVIBRATORS

05/10/2017

Displacement error (e_d):

It is defined as the ratio of maximum deviation of the actual sweep from the linear sweep to the amplitude of the sweep voltage



$$e_d = \frac{\text{Maximum Deviation}}{\text{Sweep amplitude}}$$

$$= \frac{|V_s - V_s'|_{max}}{V_s}$$

Since the actual sweep V_s is exponential

hence $V_s = V(1 - e^{-t/RC})$

$$V_s = \frac{Vt}{RC}\left(1 - \frac{t}{2RC}\right) \quad (\because \text{by evaluating})$$

The Ideal Ramp is given as

$$V_s' = \alpha t = \frac{Vt}{RC}$$

$$\therefore \text{Deviation} = \left| \frac{V_s - V_s'}{1} \right| = \left| V_s - V_s' \right|$$

$$= \frac{Vt}{RC}\left[1 - \frac{t}{2RC}\right] - \frac{Vt}{RC}$$

$$= \frac{Vt}{RC}\left[1 - \frac{t}{2RC} - 1\right]$$

$$= \frac{Vt}{RC}\left[-\frac{t}{2RC}\right]$$

$$|V_s - V_s'| = \frac{Vt}{RC} \times \frac{t}{2RC}$$

Max. deviation is at $t = \frac{T_s}{2}$ and it is

$|V_s - V_s'|_{max}$.

$$\therefore |V_s - V_s'|_{max} = \frac{V\frac{T_s}{2}}{RC} \times \frac{\frac{T_s}{2}}{2RC}$$

$$= \frac{V T_s}{2RC} \times \frac{T_s}{4RC} \longrightarrow (1)$$

We have $V_s' = \frac{Vt}{RC}$ at $t = T_s$ and $V_s' = V_s$

$$\therefore V_s = \frac{V T_s}{RC} \text{ from} \longrightarrow (2)$$

$$\therefore \text{Displacement error } e_d = \frac{\frac{VT_s}{2RC} \times \frac{T_s}{4RC}}{\frac{VT_s}{RC}}$$

$$e_d = \frac{T_s}{8RC}$$

Interrelationship of e_d, e_s and e_t:

We have

$$e_d = \frac{T_s}{8RC}$$

$$e_s = \frac{T_s}{RC}$$

$$\therefore e_d = \frac{1}{8} \times e_s$$

and we know $e_t = \dfrac{T_s}{2RC}$

$$\therefore e_d = \frac{1}{4} \times e_t$$

$$\boxed{\therefore e_d = \frac{1}{8} e_s = \frac{1}{4} e_t}$$

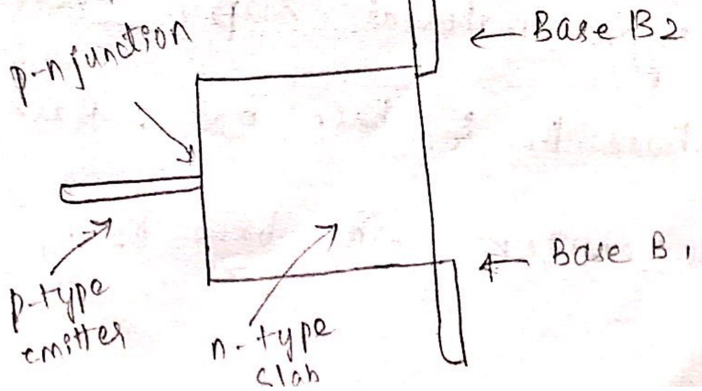
If one of the error is more, the other errors can be computed on the basis of above relationship.

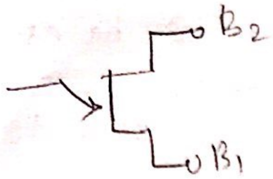
UJT sweep Generator:-

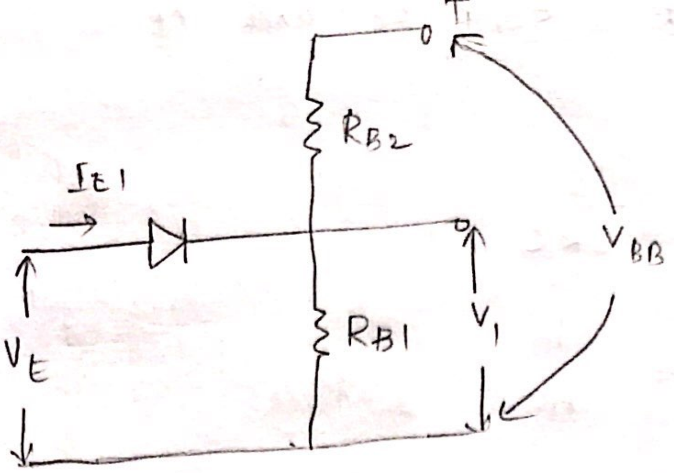
The UJT sweep Generator is also called Relaxation oscillator (which generates other than sinusoidal wave)

$V_E < V_P$, UJT is OFF

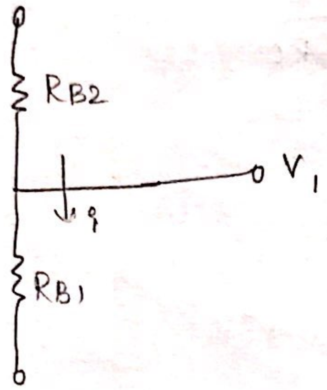
$V_E > V_P$, UJT is ON







$$V_1 = i\, R_{B1}$$



$$\text{But } i = \frac{V_{BB}}{R_{B1} + R_{B2}}$$

$$V_1 = \left[\frac{R_{B1}}{R_{B1} + R_{B2}} \right] V_{BB}$$

$$\text{where } \eta = \frac{R_{B1}}{R_{B1} + R_{B2}}$$ [Intrinsic stand off ratio]

$$V_1 = \eta \cdot V_{BB}$$

Peak voltage

$$V_p = V_\gamma + V_1$$

$$V_p = V_\gamma + \eta V_{BB}$$

→ A UJT has only one p–n junction. A Feedback emitter is alloyed to a lightly dopped n-type material slab. There are 2 bases, base B_1 & base B_2. Base B_1 being closer to the emitter than base B_2.

The p-n junction is formed between p-type emitter and n-type silicon slab. R_{B1} is the resistance between Base B_1 and the emitter and it is a variable resistance and its value depend upon the emitter current I_E. R_{B2} is the resistance between Base B_2 and the emitter and its value is fixed. Let $I_E = 0$ due to the applied voltage V_{BB}. A current I results as shown above

From the equivalent circuit, it is evident that the diode cannot conduct unless the emitter voltage $V_E = V_\gamma + V_1$

where V_γ is the cuttin voltage of Diode

This value of the emitter voltage which makes the diode conduct is termed as peak voltage and is denoted as V_p.

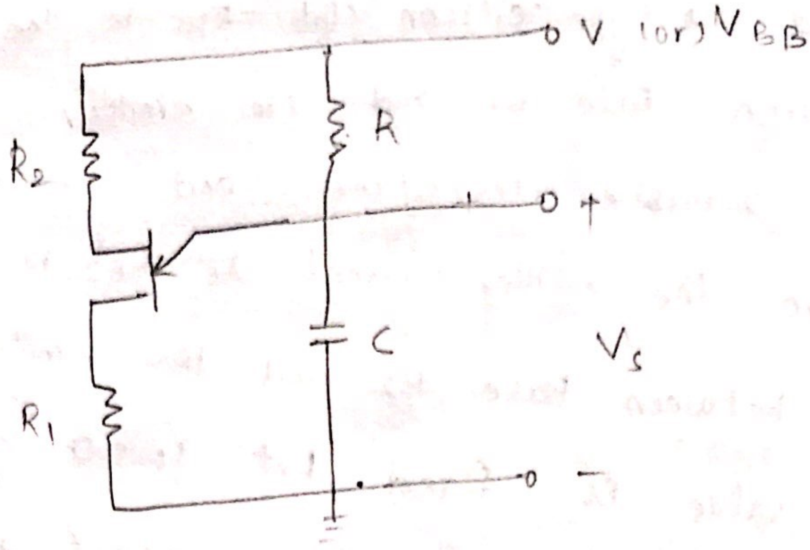
ie, $V_p = V_\gamma + V_1$ (or)

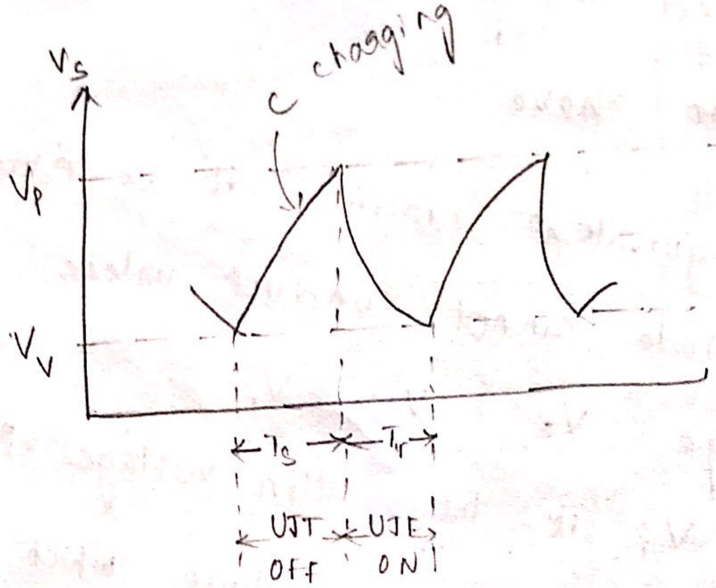
$V_p = V_\gamma + \eta V_{BB}$ $(\because V_1 = \eta V_{BB})$

Hence if $V_E < V_P$. the UJT is OFF and

if $V_E > V_P$. the UJT is ON.

Working of UJT relaxation oscillator:- (or) UJT sweep circuit





T_s - Sweep time

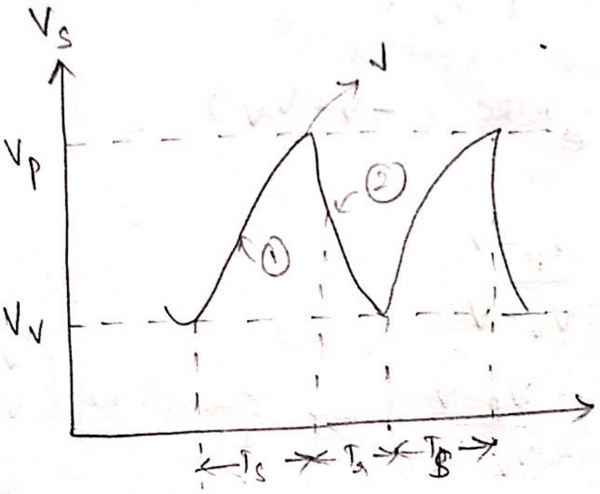
T_r - return time

V_v - Valley Voltage

The UJT is Off as long as $V_E < V_p$. the peak voltage hence when UJT is OFF capacitor c charges to the resistance R from the supply voltage 'V' and let V_s be the capacitor voltage if the capacitor voltage V_s rises to the value V_p. The UJT that readily conducts. when the

UJT becomes ON, the capacitor discharges and its voltage falls. when the voltage falls to the valley point V_p The UJT becomes OFF & the capacitor charges again to peak voltage V_p. This cycle of charging and discharging of capacitor repeats and as a result a sawtooth waveform of voltage across 'c' is generated.

Expression for Frequency 'F':-



① charging of capacitor when UJT is off

② Discharging of capacitor when UJT is on

V = Maximum value of V_s

Let V_{in} denote the initial value and V_f denote the final value of V_s. We have $V_{in} = V_v$ and $V_f = V$ during the interval 't_s'. the UJT is OFF, the capacitor charges and V_s increases exponentially. It is given by

$$V_s = V_f - (V_f - V_{in}) e^{-t/RC}.$$

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$$V_s = V - (V - V_v)\, e^{-t/RC}$$

at $t = T_s$ we have $V_s = V_p$

$$V_p = V - \left((V - V_v)\, e^{-T_s/RC}\right)$$

$$V_p \cancel{(1 - e^{-T_s/RC})} + V_v\, e^{-T_s/RC}$$

$$\cancel{e^{-T_s/RC}} = 1 - \frac{V_p}{V_D}$$

$$-T_s/RC = \log\left(\frac{V_p}{V_n}\right)$$

$$\frac{T_s}{R_C} = -\ln\frac{V_p}{V_n}.$$

$$V_p = V - V e^{-T_s/RC} + V_v\, e^{-T_s/RC}$$

$$V_p - V = \cancel{\text{Veloto}}\; e^{-T_s/RC}\,(-V + V_v)$$

$$e^{-T_s/RC} = \frac{V_p - V}{V_v - V}$$

$$-T_s/RC = \log\left(\frac{V_p - V}{V_v - V}\right) \Rightarrow \frac{T_s}{RC} = \log\left(\frac{V - V_p}{V - V_v}\right)$$

$$\frac{T_s}{R_c} = \log\left(\frac{V - V_v}{V - V_p}\right)$$

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

where $T = T_s + T_r$ but $T_r << T_s$

$$\therefore\ T = T_s$$

$$f = \frac{1}{T_s}$$

$$= \frac{1}{RC\,\log_e\left(\frac{V}{V - V_p}\right)} \qquad (\because V_v << V)$$

$$f = \frac{1}{Rc \log_e \left(\frac{1}{1 - \frac{V_p}{V}} \right)}$$

we know $V_p = \underbrace{V_d}_{\text{neglected}} + \eta V_{BB}$

$$V_p = \eta V_{BB}$$

$$V_p = \eta V.$$

$$f = \frac{1}{Rc \log_e \left(\frac{1}{1 - \frac{\eta V}{V}} \right)}$$

$$= \frac{1}{Rc \log_e \left(\frac{1}{1-\eta} \right)}$$