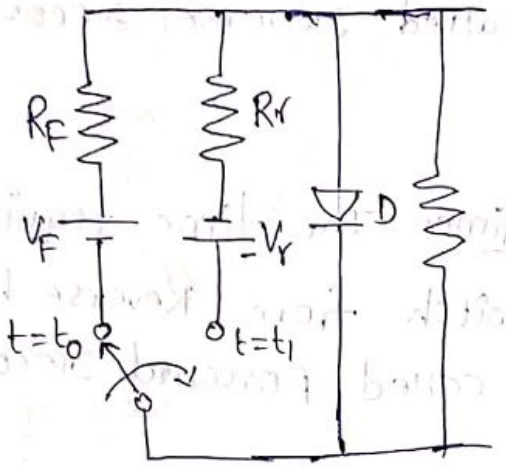
UNIT-3

Switching characteristics of Devices

1. Diode as a Switch

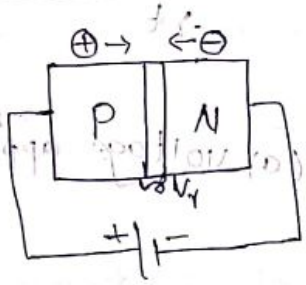


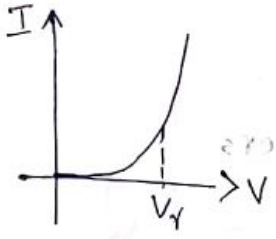
at $t=t_0$, D-ON, S.C $\Rightarrow I_f = \frac{V_F}{R_f}$

at $t=t_1$, D-OFF, O.C $\Rightarrow I_R = \frac{-V_R}{R_r}$

Hence diode is working as switch.

Piece wise linear characteristics of diode:-





practical diode

V_γ = finite

R_f = finite

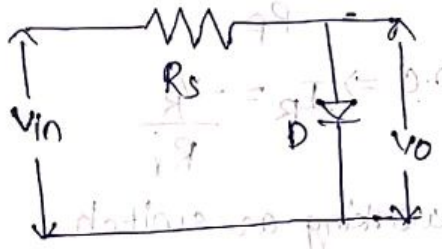
$R_r = \infty$

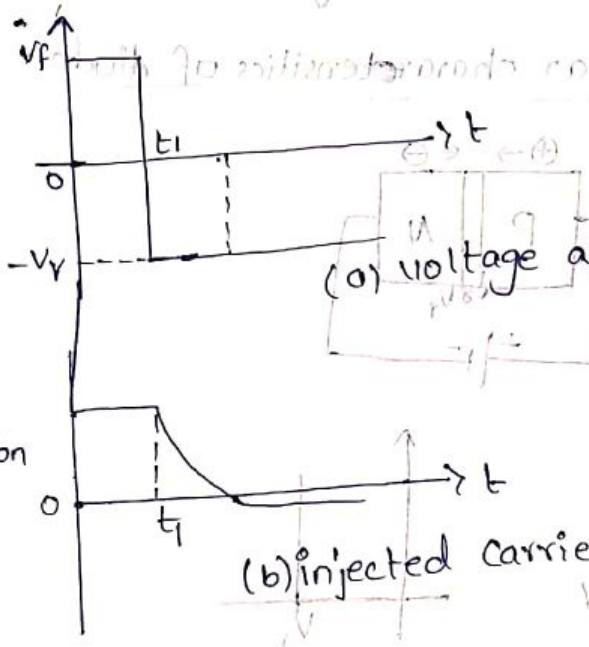
www.Jntufastupdates.com Scanned by CamScanner

Diode switching times:-

Reverse Recovery time:- The time required for the diode to switch from forward bias to reverse bias is called reverse recovery time (t_{rr}).

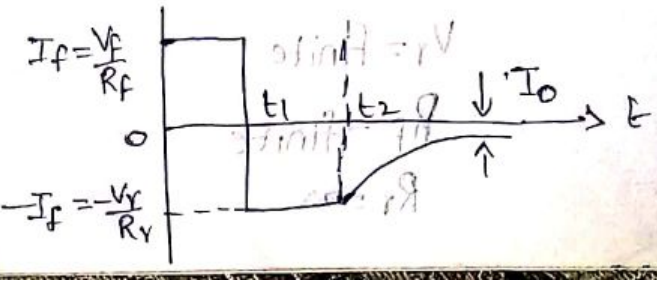
Forward Recovery time:- The time required for the diode to switch from Reverse bias to forward bias is called forward recovery time (t_{fr}).



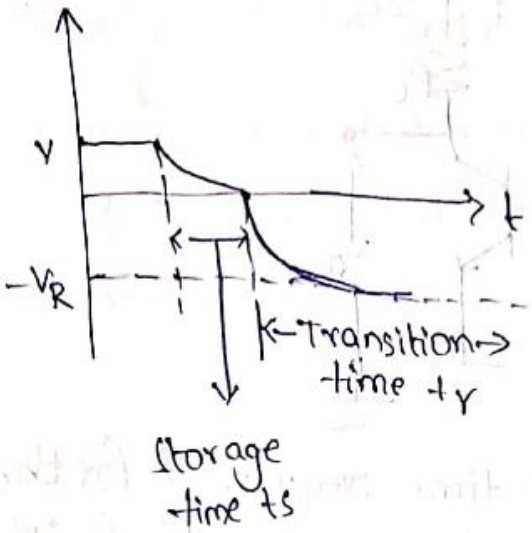


(a) voltage applied to a diode

(b) injected carriers



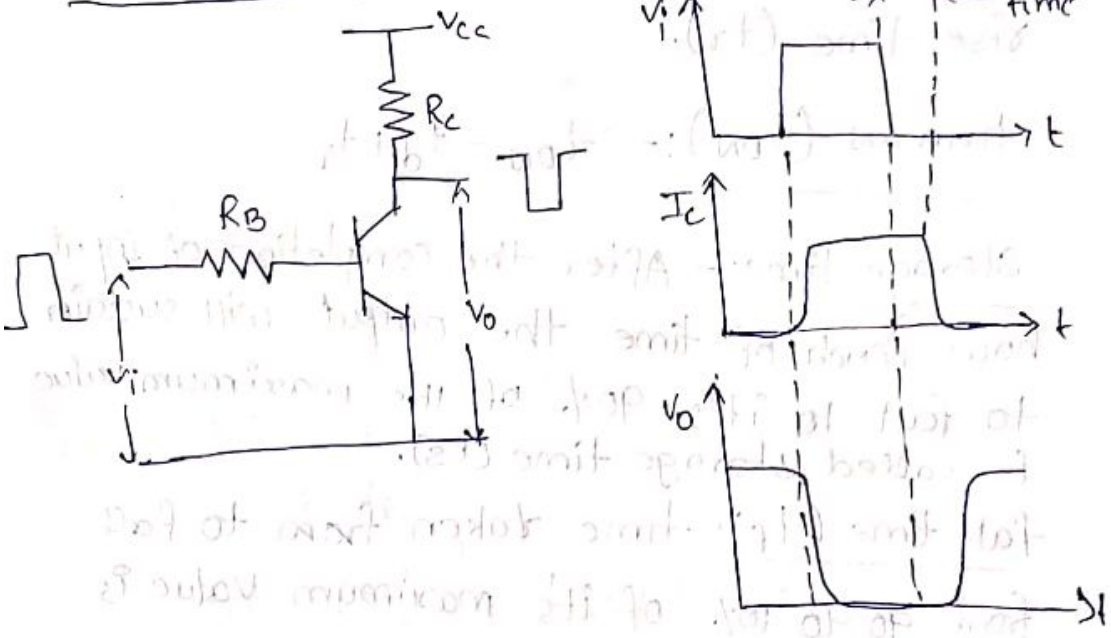
www.Jntufastupdates.com Scanned by CamScanner



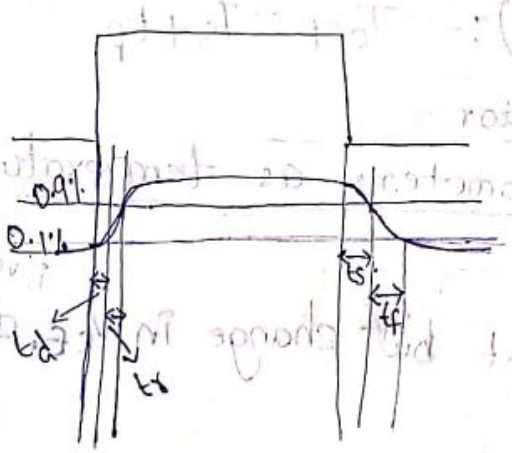
(d) diode voltage

Storage time

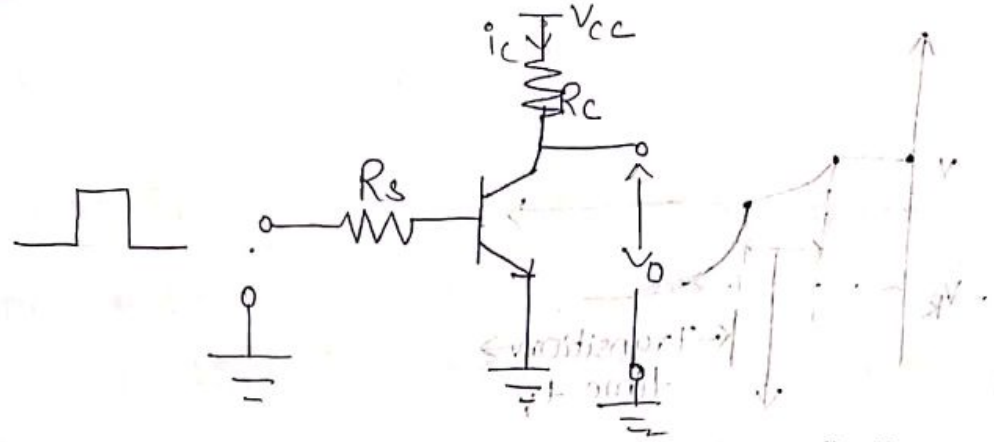
Transistor as a switch:-



Transistor switching Times:-



www.Jntufastupdates.com Scanned by CamScanner



Delay time (t_d):- time required for the device to attain initial level to 10% of it's final value is called delay time (t_d).

Rise time (t_r):- time required to reach 10 to 90% of it's maximum value is called rise time (t_r).

turn ON (t_{ON}):- $t_{ON} = t_d + t_r$

Storage time:- After the completion of input how much of time the output will sustain to fall to it's 90% of its maximum value is called storage time (t_s).

fall time (t_f): time taken from to fall from 90 to 10% of it's maximum value is called fall time (t_f).

Turn off (T_{OFF}):- $T_{OFF} = t_s + t_f$

Designing of Transistor:-

Saturation Parameters as temperature dependent:

1. I_B, I_C constant but change in V_{CE} is vary due to temp dependent.

www.Jntufastupdates.com Scanned by CamScanner

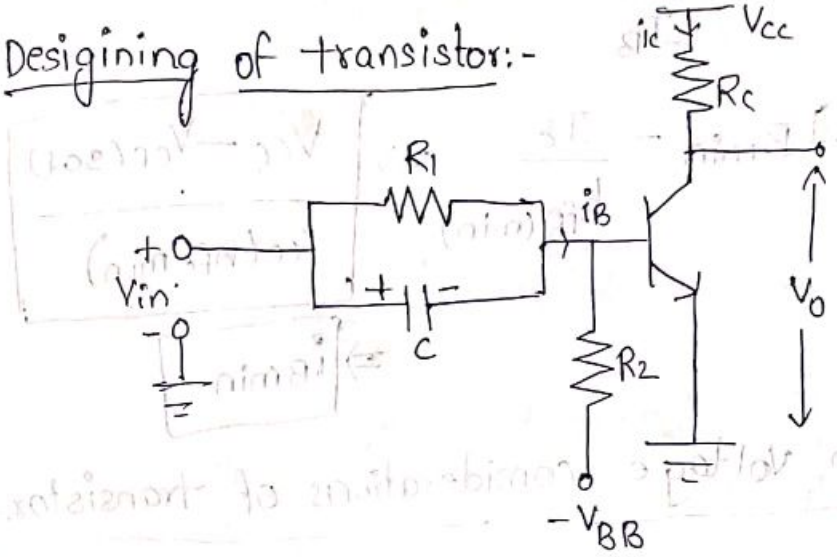
2. Senstivity -1.5 to 2 mv/°c

3. for small signal analysis holes and electrons will get cancel. but higher order it is not use.

4. current amplification factor $h_{fe} = \frac{I_C}{I_B}$.

5.

Designing of transistor:-



$$i_c = \frac{V_{CC} - V_{CE(sat)}}{R_c}$$

$$i_B = i_1 - i_2$$

$$= i_{R_1} - i_{R_2}$$

$$V_{BE} = \left(V_{in} - (-V_{BB})\right)\left(\frac{R_2}{R_1 + R_2}\right)$$

$$i_{R_1} = i_1 = \frac{[V(1) - V(0)] - V_{BE(sat)}}{R_1}$$

$$i_{R_2} = i_2 = \frac{V_{BE(sat)} - (-V_{BB})}{R_2'} = \frac{V_{BE(sat)} + V_{BB}}{R_2}$$

$$i_B = i_{R_1} - i_{R_2}$$

$$= \frac{[V(i) - V(0)] - V_{BE(sat)}}{R_1} - \frac{V_{BE(sat)} + V_{BB}}{R_2}$$

$$\beta = h_{fe} \Rightarrow \frac{I_C}{I_B}$$

$$I_{B\min} = \frac{I_C}{h_{fe(\min)}} \Rightarrow \boxed{\frac{V_{CC} - V_{CE(sat)}}{R_C(h_{fe}\min)}}$$

$$\Rightarrow \boxed{i_{B\min}}$$

Break down voltage considerations of transistor:-

The minimum voltage upto which the device can conduct in reverse bias is called break down voltage at collector base function at emitter

i.e., BV_{BCO}

$$M = \frac{1}{1-\left(\frac{V_{BC}}{BV_{BCO}}\right)^n} \quad \text{for } n \Rightarrow 2 < n < 20$$

common Base mode (α) $\Rightarrow \frac{I_C}{I_E}$

common Emitter $\beta = \frac{I_C}{I_B} = \frac{\alpha}{1-\alpha} = \frac{\alpha M}{1-\alpha M}$

$$\boxed{h_{fe}' = \frac{\alpha'}{1-\alpha'}} \qquad \boxed{\alpha M = \alpha'}$$

$(\because \beta = h_{fe}')$

www.Jntufastupdates.com Scanned by CamScanner

$\alpha \simeq 1 \Rightarrow$ then $I_C = \infty$

$$M = \frac{1}{1-\left(\frac{V_{BC}'}{BV_{BCO}}\right)^n} \simeq \frac{1}{\alpha}$$

$$\Rightarrow 1-\left(\frac{V_{BC}}{BV_{BCO}}\right)^n = \alpha$$

$$\left(\frac{V_{BC}}{BV_{BCO}}\right)^n = 1-\alpha$$

$$\left(\frac{V_{BC}}{BV_{BC_O}}\right) = n\sqrt{1-\alpha}$$

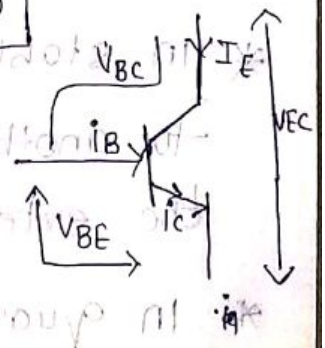
$$\Rightarrow \boxed{V_{BC} = BV_{BCO}\, n\sqrt{1-\alpha}}$$

$V_{CE} = V_{BC} + V_{BE}$ Small

$\boxed{V_{BE} = 0}$

$\boxed{V_{BC} = V_{CE}}$

$\rightarrow V_{CE} = BV_{BCO}\, n\sqrt{1-\alpha}$



www.Jntufastupdates.com Scanned by CamScanner

Multivibrators:-

Multiviberators:-

A device which is used to generate oscillations of different frequencies is called multivibrator.

In a multivibrator, multi means many Vibrator means oscillator.

Any multivibrators consists of two possible states.

1) stable state
2) quasistable state (temporary stable)

the classifications

* In stable state, to change from one state to another state, it is being done by only the external application of trigering pulse.
* In quasi stable state, no external triggering is required, after a pre-defined time it will move from quasi state to stable state

Multivibrators are classified into three types:

1) Bistable
2) Monostable
3) Astable

www.Jntufastupdates.com Scanned by CamScanner

Multivibrator	stable state	qusi stable state
Bistable	2	0
Monostable	1	1
Astable	0	2

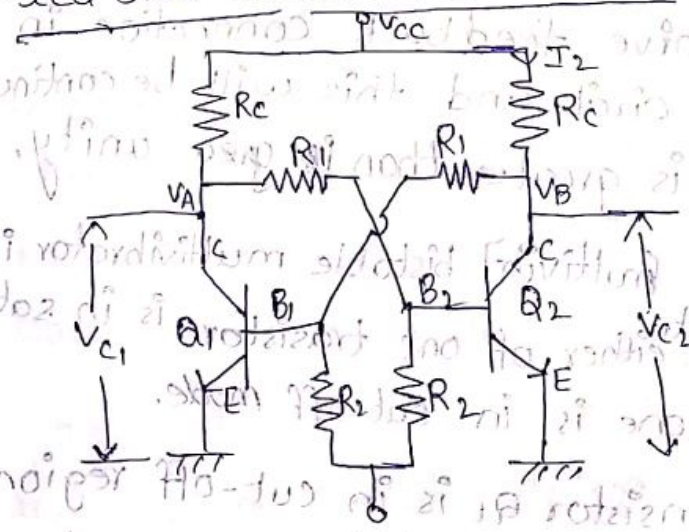
Bistable Multivibrator:-

The bistable multivibrator consists of two stable states. The bistable multivibrator is also known as Flipflop, trigger, binary circuit, and Eccles Jordan circuits.

* The bistable multivibrator is classified into 2 types
  a) collector coupled bistable multivibrator
  b) Emitter base coupled bistable " (schmitt trigger)

* collector coupled bistable Multivibrator is classified into two types:
  1) fixed bias
  2) self bias

fixed bias bistable Multivibrator:-



www.Jntufastupdates.com Scanned by CamScanner

* In fixed bias multistable multivibrator two symmetrical Resistors transistors are cross-coupled through DC couplers such that the output of first transistor is connected to i/p of second transistor and vice versa.

* for the analysisation of this multivibrator let us assume that their are small fluxations in current levels that is $I_1 > I_2$.

* If I_1 is more then the voltage drop across the collector of first transistor is very much more then the potential at a point A (V_A) is low.

* The minimum voltage at a point V_A is applied to the base of second transistor i.e, Q_2 will be in cut-off mode.

* As I_2 is smaller then the potential at a point B (V_B) is more and this will turn on transistor Q_1.

* The above action will be continued due to the regenerative feedback connection in coporative in cirat and this will be continue. the loop gain is greater than unity.

* The desiging of multivib bistable multivibrator is one in stable state either of one trasistors is in saturation and remaining one is in cut-off mode.

* Let the transistor Q_1 is in cut-off region and Q_2 is in active mode, due to the temperature variations and aging of components, some times the

www.Jntufastupdates.com Scanned by CamScanner

drift current may be very high their may be a possibiliey of the transistor Q_2 will fall down to cut-off mode from active mode, unless it is useless

selection of components in a bistable multivibrator:-

(or) conditions in a multivibrator to be stable state.

If the transistor Q_1 is in off condition then at the collector terminal we may get full V_{CC}. If Q_1 is in saturation then I_C is very high then their may be a possibiliey of break -down.

i.e V_{CC} should be limited in a such a manner that it is lower than V_B 'BVCEO'.

Hence V_{CC} is limited with few tens of volts.

R_C should be selected such that it's satisifies $I_C = \frac{V_{CC}}{R_C}$ condition.

the values V_{CC}, V_{BB}, R_1, R_2 should be selected, however, in one stable state the transistor must be in saturation mode and in an other stable state the emitter base Junction should be cut-off.

the difference in the voltage levels V_{C1} and V_{C2} is called voltag swing. i.e,

$$V_W = V_{C1} - V_{C2}$$

www.Jntufastupdates.com Scanned by CamScanner

components

loading:-

The bistable multivibrator, sometimes the one (or) both of collectors have to lead other circuits.

Let the transistor Q_1 is off then the off transistor is loaded by Resistor 'R_1'. Hence R_1 should be as large compare to R_c.

The multivibrator should be design in such a way under heaviest load, one transistor is in saturation and second one is in cut-off.

To maintain the loop gain in excess of unity we must select R_1 & R_c by $R_1 < h_{fe} R_c$ that is called loading.

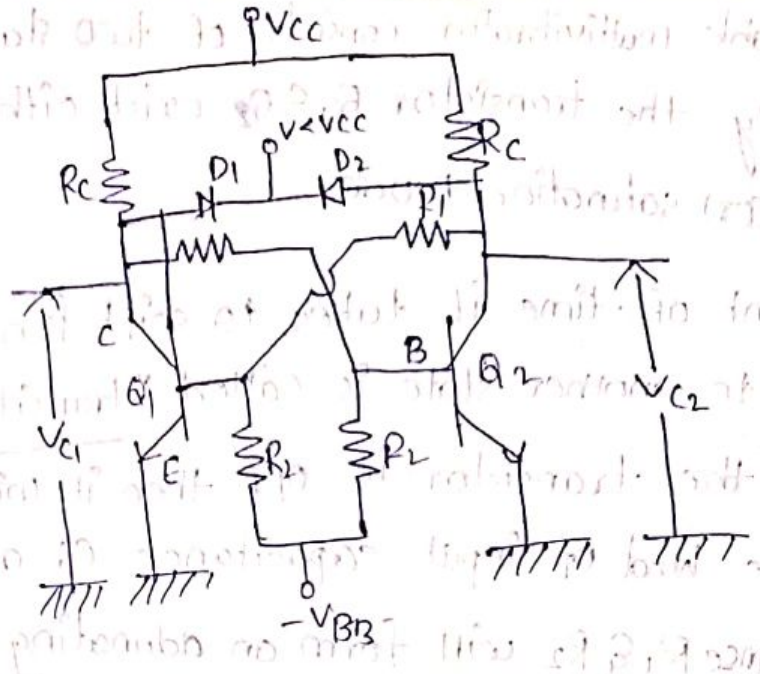
(or)

In a bistable multivibrator, the off transistor is loaded by R_1, produce an increasing collector potential which results increased I_c, and it is being given to I_{B_2} which may be insufficient to make other transistor turn on.

collector catching diodes:-

The collector catching diodes are connected in b/w the collectors of Q_1 & Q_2

www.Jntufastupdates.com Scanned by CamScanner

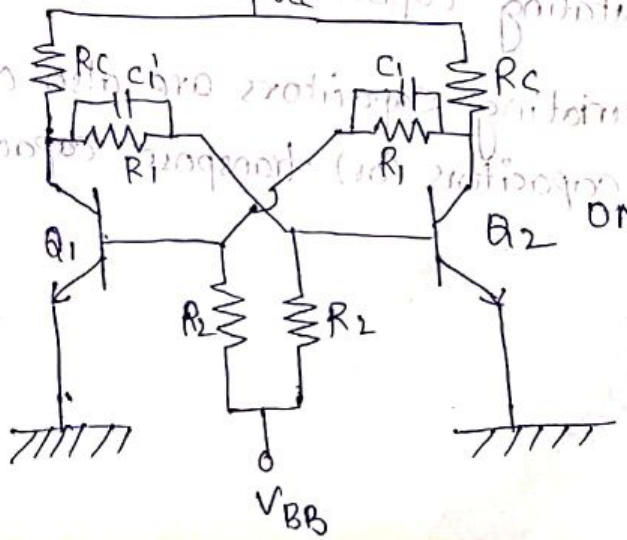


Bistable multivibrator with collector catching diodes.

* The collector catching diodes are connected in b/w the collectors of Q_1 & Q_2.
* The purpose of catching diodes is to eliminate the o/p voltage swing there by producing fixed o/p levels.
* wherever the collector voltage reaches a fixed level 'V' then the diode D_1 gets conduct and it clamps to a level $V < V_{CC}$

commutating capacitors:

* the commutating capacitors are also called speed up capacitors (or) transpose capacitors.



www.Jntufastupdates.com Scanned by CamScanner

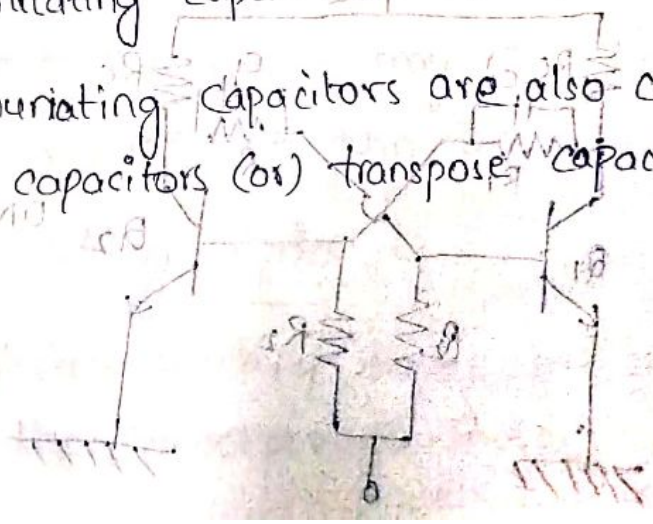
As the bistable multivibrator consists of two stable states usually the transistor Q_1 & Q_2 exist either in cut-off (or) saturation mode.

* The amount of time it takes to shift from one state to another state is called "transition time". If the transistor is off then it will have some what of input capacitance C_i and the resistance R_1 & R_2 will form an adunating n/w i.e, $R_1 \| R_2$. so, with the help of these their is a time delay of $\tau = (R_1 \| R_2)C$.

* The resolving time can be defined as the amount of time gap blw the application of two triggering pulses. the settling time may be the defined as the amount of time that the capacitances C_i and C_i' takes to settledown. the combination of transition time and settling time is called resolution time.

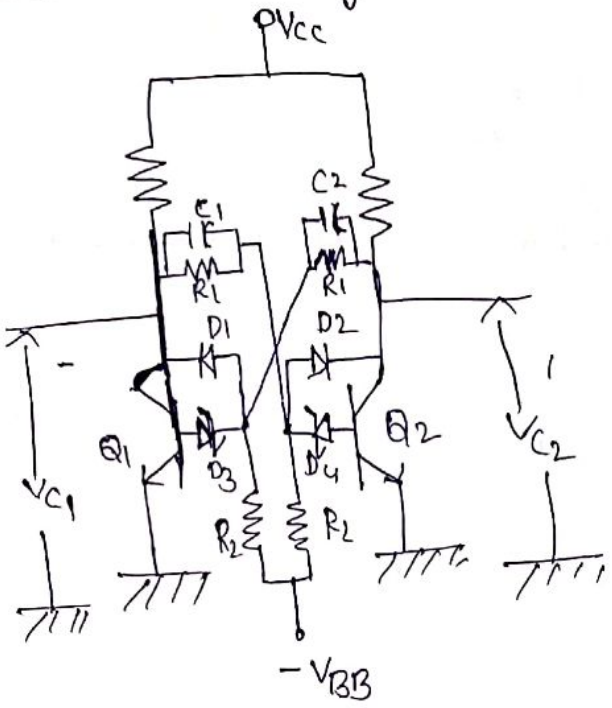
* The delay in switching from one state to another state can be limited by the introduction of communitating capacitors C_i and C_i'

* The communiating capacitors are also called as speed up capacitors (or) transpose capacitors.



www.Jntufastupdates.com Scanned by CamScanner

Non saturated Binary circuit



Types of triggering a Binary:-

* Triggering is a process where the circuit goes into functioning by the application of external signal.

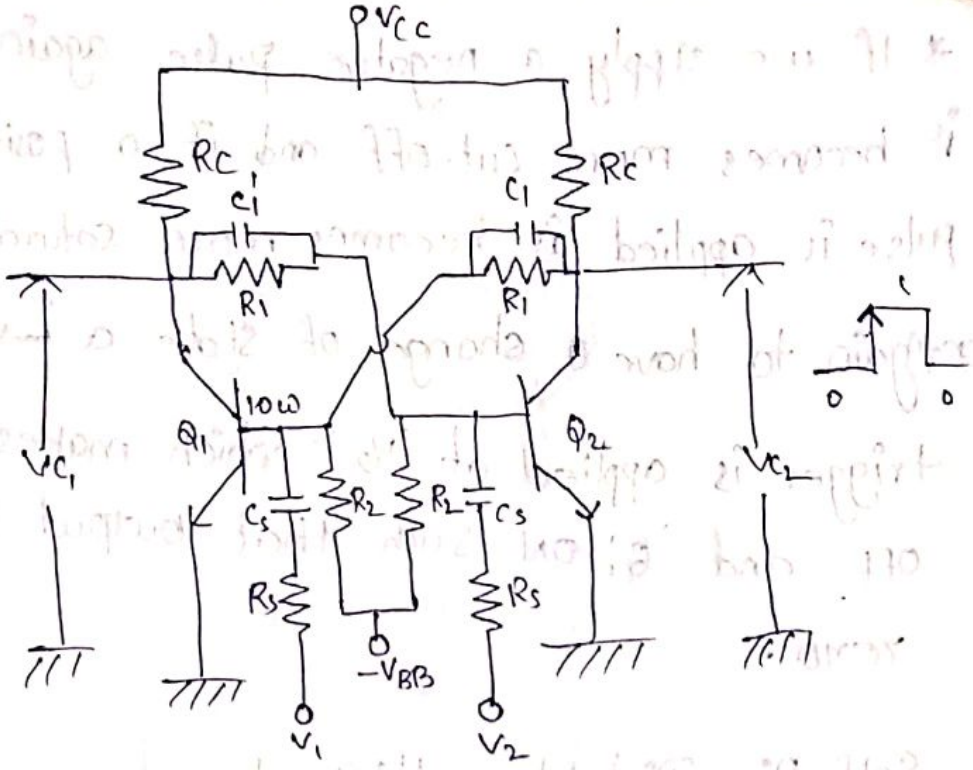
* the circuit which generates triggering pulse is called trigger circuit.

*triggerings are classified into two types:-

1) Symmetric triggering
2) Asymmetric triggering.

ASymmetric triggering of Binary:-

www.Jntufastupdates.com Scanned by CamScanner



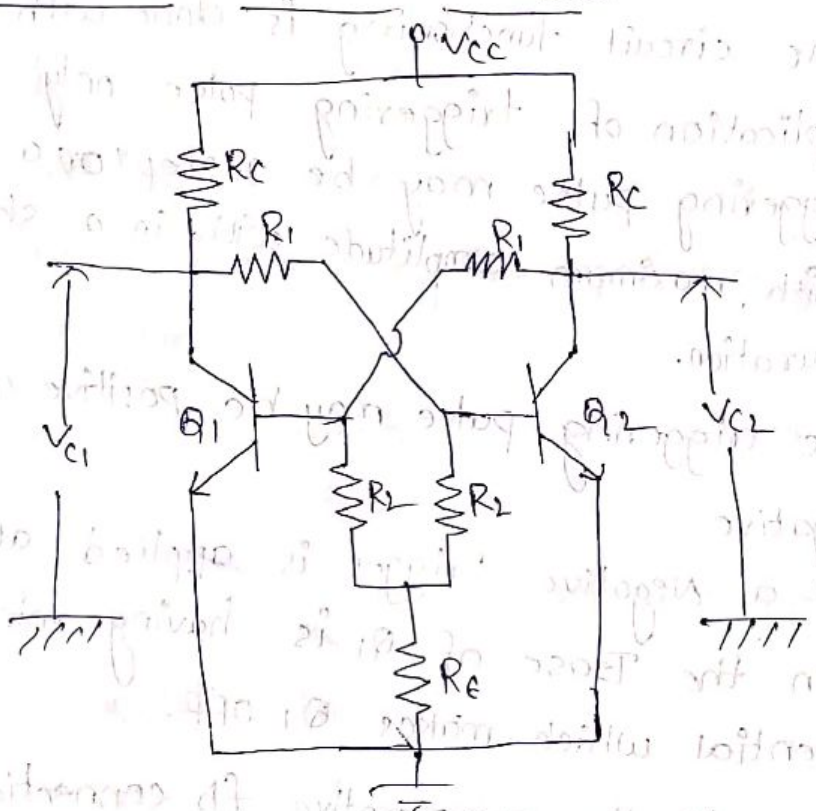
* The circuit functioning is done with the application of triggering pulse only. the triggering pulse may be a step (or) a pulse with maximum amplitude with in a short duration.
* The triggering pulse may be positive (or) Negative.
* If a Negative trigger is applied at V_1 then the Base of Q_1 is having minimum potential which makes Q_1 OFF.
* Due to the regenerative fb connection If Q_1 is off and Q_2 is ON.
* By letting initial position of output is zero, by the above process output changes their state from 0 to 1.

www.Jntufastupdates.com Scanned by CamScanner

* If we apply a negative pulse again at V_1 it becomes more cut-off and if a positive pulse is applied it becomes more saturation.

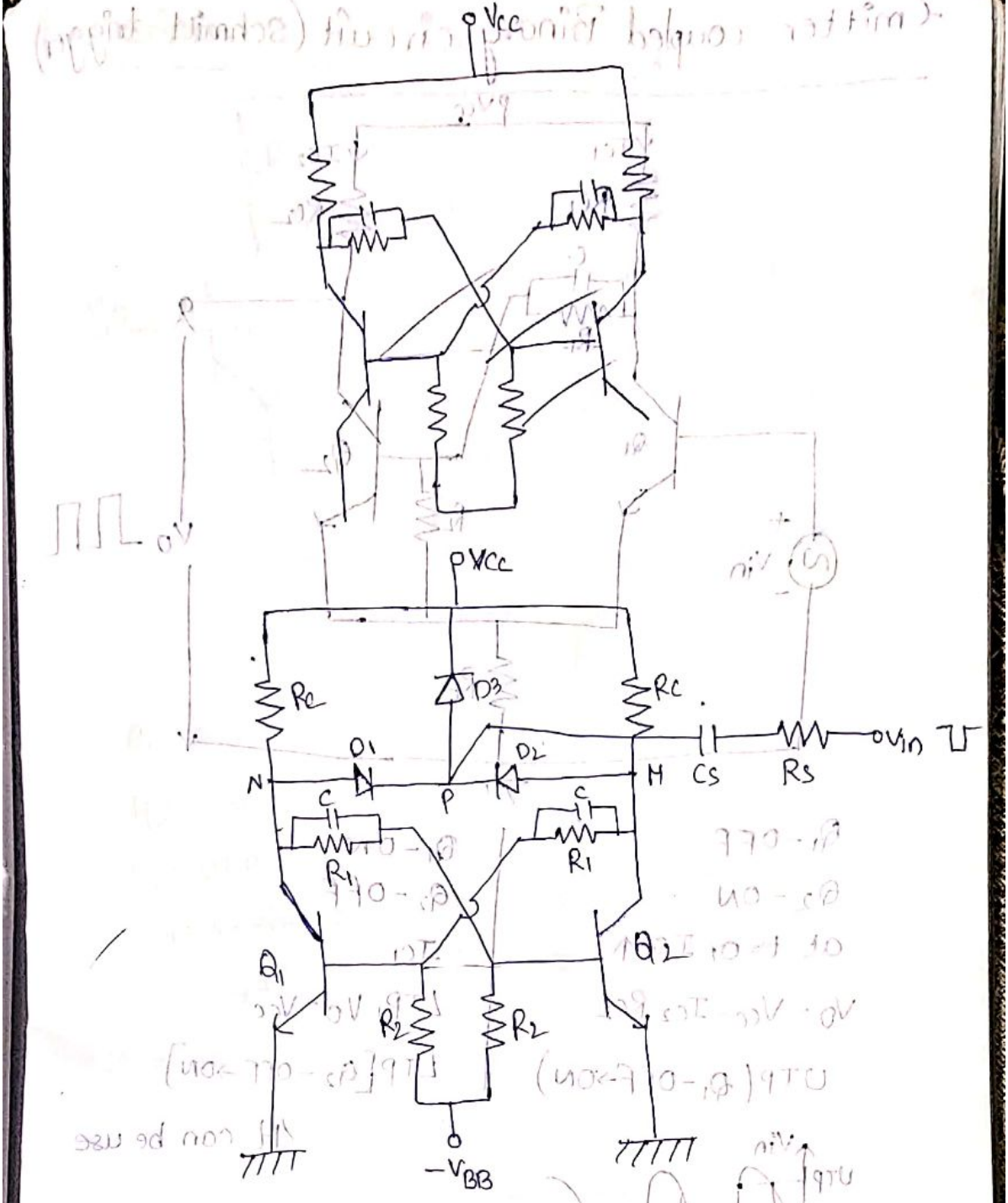
* Again to have a change of state a 've' trigger is applied at 'V_2' which makes 'Q_2' OFF and 'Q_1' ON such that output is zero.

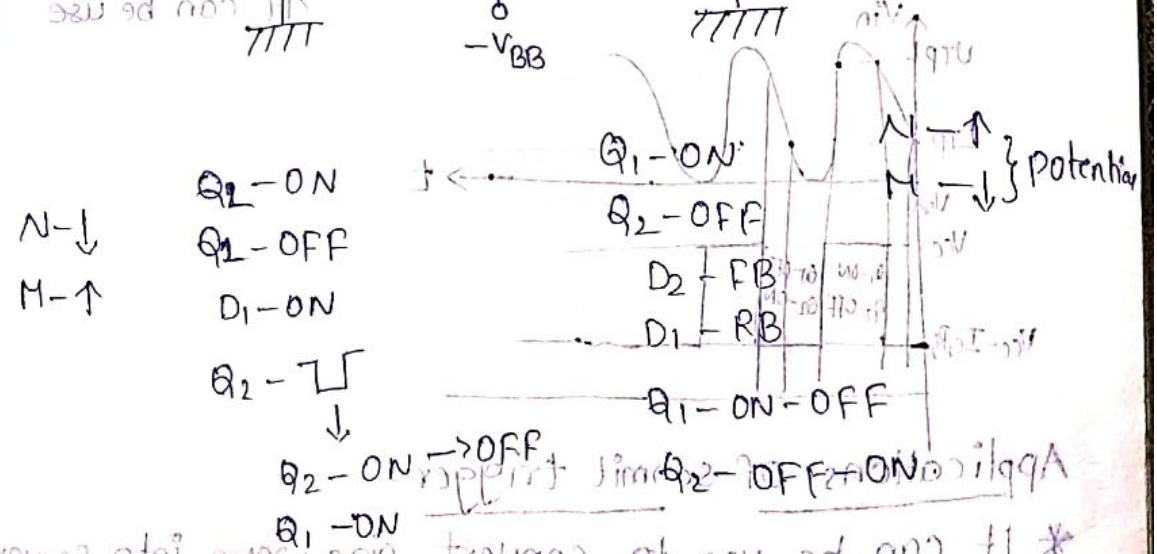
Self Bias Bistable multivibrator:-



Symmetric triggering of Binary:-

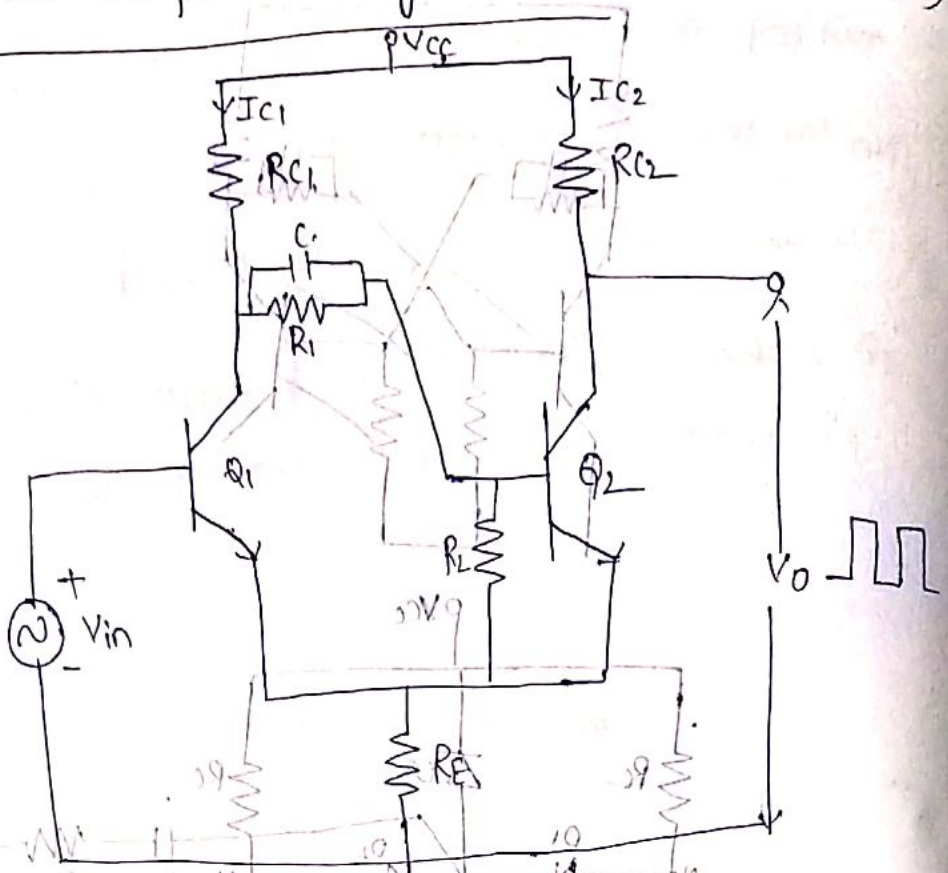
www.Jntufastupdates.com Scanned by CamScanner





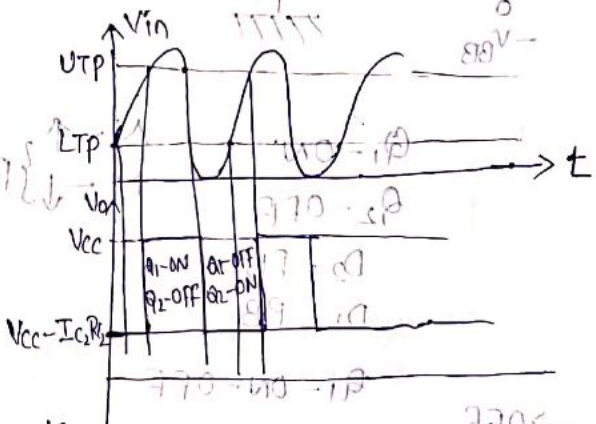
www.Jntufastupdates.com Scanned by CamScanner

Emitter coupled Binary circuit (schmitt trigger)



Q_1-OFF
Q_2-ON
at t=0, I_{C2}↑
$V_0 = V_{CC} - I_{C2}.R_{C2}$
UTP(Q_1-OFF→ON)

Q_1-ON
Q_2-OFF
I_{C1}
LTP, $V_0 = V_{CC}$
LTP[Q_2-OFF→ON]
It can be use

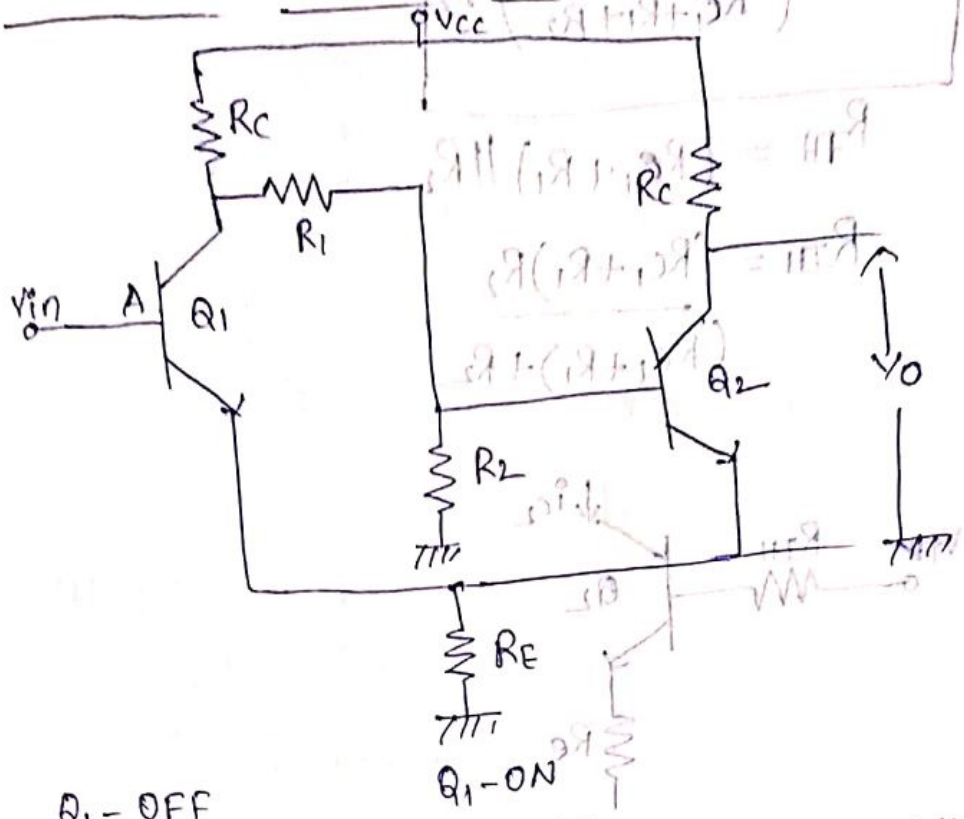


Applications of schmit trigger:

* It can be use to convert sine wave into sqware wave
* It can be used as flipflop
* It can be used as voltage

www.Jntufastupdates.com Scanned by CamScanner

Evaluation of UTP & LTP:-



Q_1 - OFF

$(Q_2$ - ON)

V_1 = UTP

$V_1 = V_\gamma + iE_2 R_E$

$V_1 = V_\gamma + ic_2 R_E$

Q_1 - ON

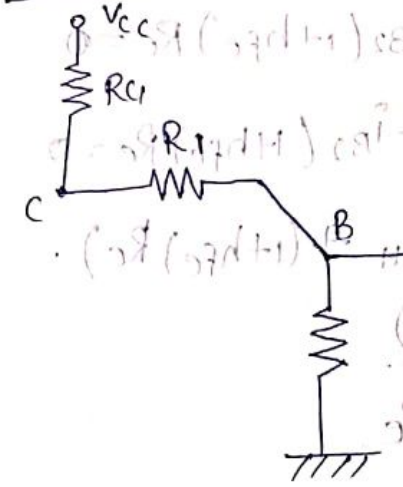
Q_2 = OFF

V_2 = LTP

$V_2 = V_{BE}(act) + FE_1 R_E$

$V_2 = V_{BE}(act) + ic_1 R_E$

Evaluation of V_1 (UTP):



Apply theviens at 'B':-

$V_{TH} = iR_2$

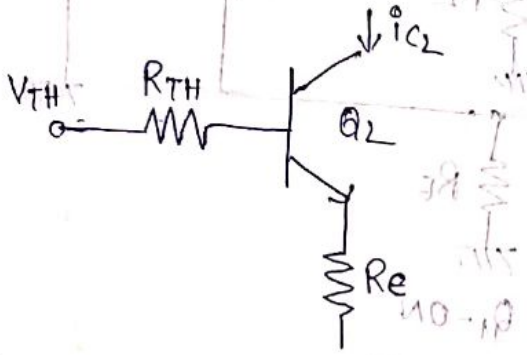
$i = \frac{V_{CC}}{(R_{C1} + R1 + R_2)}$

www.Jntufastupdates.com Scanned by CamScanner

$$V_{TH} = \left(\frac{V_{CC}}{R_{C_1}+R_1+R_2}\right) R_2$$

$$R_{TH} = (R_{C_1}+R_1) \,||\, R_2$$

$$R_{TH} = \frac{(R_{C_1}+R_1)R_2}{(R_{C_1}+R_1)+R_2}$$



KVL:- $V_{TH} - i_{B_2} R_{TH} - V_{BE_2}(act) - (i_{B_2} + i_{C_2}) R_e = 0$

$$h_{fe} = \frac{i_{C_2}}{i_{B_2}}$$

$$i_{C_2} = h_{fe}\, i_{B_2}$$

$$V_{TH} - i_{B_2} R_{TH} - V_{B_2}(act) - (i_{B_2} + h_{fe}\, i_{B_2}) R_e = 0$$

$$V_{TH} - V_{B_2}(act) - i_{B_2} R_{TH} - i_{B_2}(1+h_{fe}) R_e = 0$$

$$V_{TH} - V_{B_2}(act) = i_{B_2} R_{TH} + i_{B_2}(1+h_{fe}) R_e = 0$$

$$V_{TH} - V_{B_2}(act) = i_{B_2}\left(R_{TH} + (1+h_{fe}) R_e\right).$$

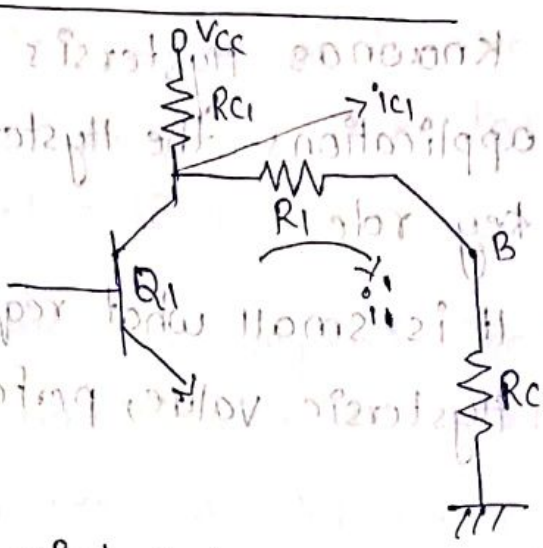
$$i_{B_2} = \frac{V_{TH} - V_{BE}(act)}{R_{TH} + (1+h_{fe}) R_e}$$

W.K.T $i_{C_2} = i_{B_2} h_{fe}$

$V_1 = UTP = V_1 + i_{C_2} R_e$

www.Jntufastupdates.com Scanned by CamScanner

Evaluation of V_2 (LTP):-



at point C_1 KCL

$$i + i_{C1} - i^1 = 0$$

$$i_{C1} = i^1 - i \Rightarrow i = i^1 - i_{C1}$$

$$i^1 = \frac{V}{R} = V_C\left(\frac{R_2}{R_1+R_2}\right)$$

$$i_{C1} = \frac{V_{CC} - V_C}{R_{C1}}$$

$$i = V_C\left(\frac{R_2}{R_1+R_2}\right) - \frac{V_{CC} - V_C}{R_{C1}}$$

$$i^1 = V_C\left(\frac{R_2}{R_1+R_2}\right)$$

$$V_B = V_C\left(\frac{R_2}{R_1+R_2}\right)$$

$$V_B\left(\frac{R_1+R_2}{R_2}\right) = V_C$$

$$V_B(m) = V_C$$

$$V_B(m)\left[\frac{R_2}{R_1+R_2}\right] - \frac{V_{CC} - V_B(m)}{R_{C1}}$$

$$LTP = V_{BE}(act) + V_B(m)\left[\frac{R_2}{R_1+R_2}\right] - \frac{V_{CC} - V_B(m)}{R_{C1}}$$

www.Jntufastupdates.com Scanned by CamScanner

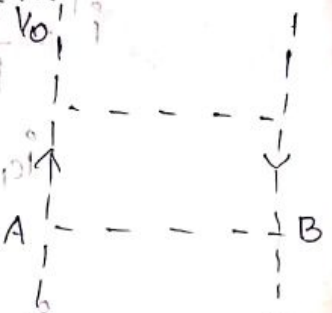
* Hystersis:- The difference b/w UTP and LTP levels is knownas Hystersis of the ckt for many applications the Hystersis value place a key role.

* In few cases it is small what required to maintain lower Hystersic value, perferable zero level.

* By adjusting the loop gain of the ckt to unity Hystersis can be elemented.

* Hystersis behaviour of symmetric.

* There are different ways for the adjustment of loop gain there by minimizing Hystersis.



1. Rc value may be increased (or) decrease, then the loop gain may be increase (or) decrease..

2. By adding R_{e1} in series with emitter of Q_1, (or) By adding R_{e2} in series with emitter, of Q_2 the loop gain can be increased (or) decreased.

3. By varying the ratio $\frac{R_2}{R_1+R_2}$, the loop gain can be varied. such that both V_1 & V_2 are change due to the adjustment.

www.Jntufastupdates.com Scanned by CamScanner

4. The gain would be less than unity and there is no change in the ckt state. If R_{e1} R_{e2} larger is than the value required to get zero Hysterisis.

5) A collector coupled fixed bias binary uses NPN - transistor with $h_{fe} = 100$ the ckt parameters are $V_{CC} = 12V$, $V_{BB} = -3V$, $R_C = 1K\Omega$, $R_1 = 5K\Omega$, $R_2 = 10K\Omega$. verify that when one transistor is cut-off other is in saturation and find the stable state currents and voltages for the ckt. Assume for transistors $V_{CE(sat)} = 0.3V$, $V_{BE} = 0.7V$.

Sol :- $h_{fe} = 100$

$V_{CC} = 12V$

$V_{BB} = -3V$

$R_C = 1K\Omega$

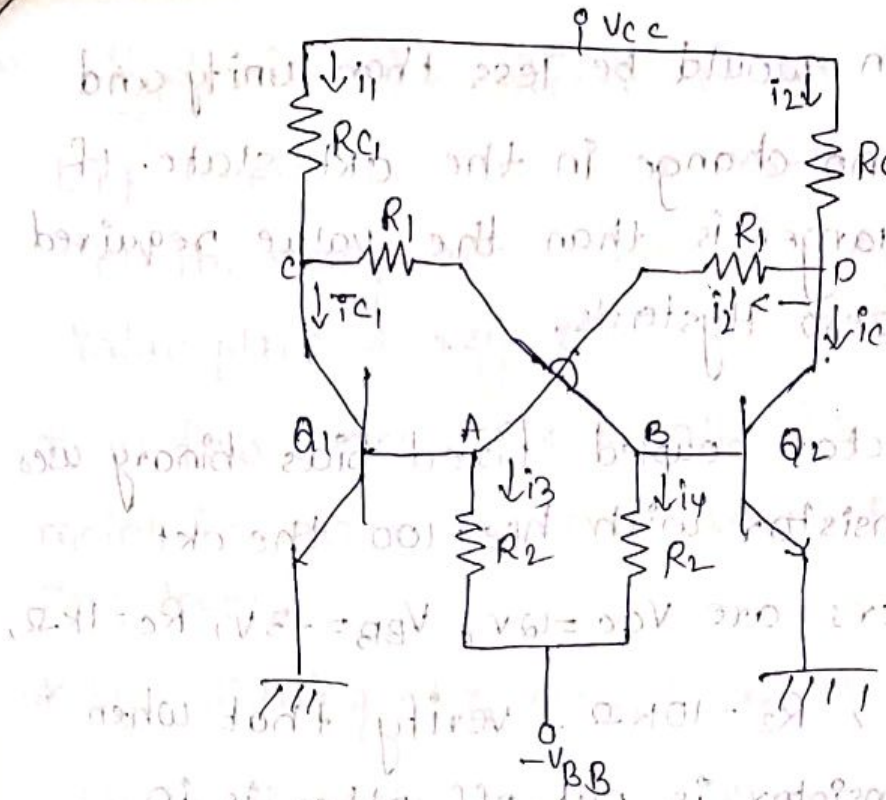
$R_1 = 5K\Omega$

$R_2 = 10K\Omega$

$V_{CE(sat)} = 0.3V$

$V_{BE(sat)} = 0.7V$

www.Jntufastupdates.com Scanned by CamScanner

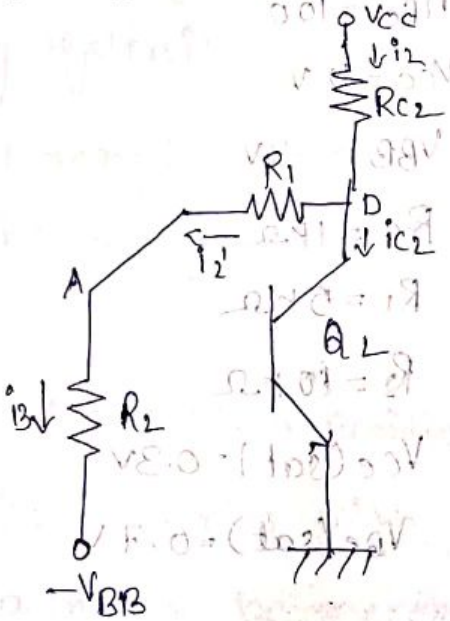


Let, If Q_1 is off, Q_2 is ON.

$i_{B_1} = 0$, $i_{C_1} = 0$

$V_{BC_2}(sat) = V_D = 0.3V$

$V_{BE_2}(sat) = V_B = 0.7V$



$$i_2 = \frac{V_{cc} - V_D}{R_{c_2}}$$

$$= \frac{12 - 0.3}{10}$$

$$i_2 = 11.7mA$$

$$i_2 = i_{c_2} + i_2'$$

$$i_2' = \frac{V_D - (-V_{BB})}{R_1 + R_2}$$

$$i_2' = \frac{0.3 + 3}{5 + 10} = 0.22mA$$

www.Jntufastupdates.com Scanned by CamScanner

$$h_{fe} = \frac{i_{C_2}}{i_{B_2}}$$

$$100 = \frac{11.48\ mA}{i_{B_2}}$$

$$i_{B_2} = \frac{11.48\ mA}{100}$$

$$\boxed{i_{B_2} = 0.1148}$$

To find the value of V_C

$$V_C = V_{CC} - i_1 R_{C_1}$$

$$i_1 = \frac{V_{CC} - V_B}{R_{C_1} + R_1}$$

$$= \frac{12 - 0.7}{1.75} = \frac{11.3}{6}$$

$$\boxed{i_1 = 1.88\ mA}$$

$$V_C = 12 - (1.88)(1)$$

$$\boxed{V_C = 10.12}$$

To find the value of V_A

$$V_A = V_D - i_2' R_1$$

$$= 0.3 - (0.25)(5)$$

$$V_A = -0.8V$$

www.Jntufastupdates.com Scanned by CamScanner

V_A is < zero Q_1 is off and Q_2 is ON means in one state transistor is in cut-off and another state it act as Saturation.

It coorks as Bistable multivibrator.

www.Jntufastupdates.com Scanned by CamScanner

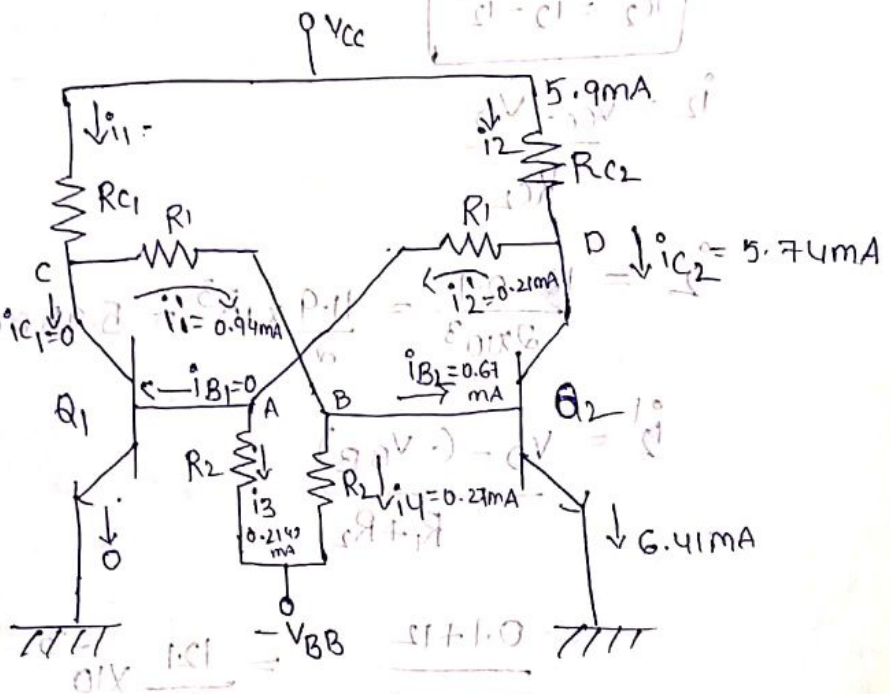
P) A fixed bias binary circuit uses a dc supply ±12V, $R_C = 2k\Omega$, $R_1 = 10k\Omega$, $R_2 = 47k\Omega$, npn silicon transistors with V_{CC} saturation = 0.1V, V_{BE} saturation = 0.7V, $H_{fe} = 30$ are used then

(i) Draw the ckt diagram and show the stable state currents assuming that Q_1-OFF, Q_2=ON.

(ii) Calculate all the currents and voltages and verify the device states.

(iii) Sketch the collector output voltage against external load current characteristic and Calculate $I_{L max}$.

Sol:-



Sol:- given that

$V_{CC} = \pm 12V$ | $-V_{BB} = -12V$

$R_C = 2k\Omega$ | $V_{CE(sat)} = 0.1V$

$R_1 = 10k\Omega$ | $V_{BE(sat)} = 0.7V$

$R_2 = 47k\Omega$ | $h_{fe} = 30$

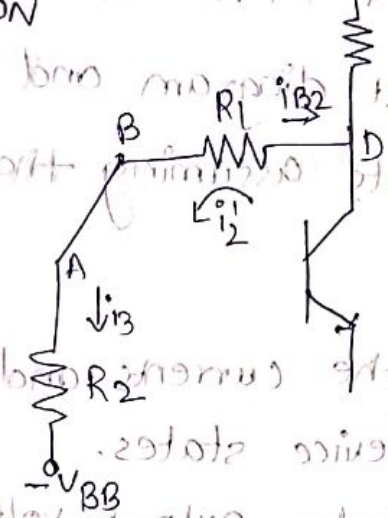
www.Jntufastupdates.com Scanned by CamScanner

If Q_1 – OFF $\rightarrow i_{B_1} = 0, i_{C_1} = 0$

Q_2 – ON $\rightarrow V_{BE(sat)} = V_B = 0.7V$

$V_{CE(sat)} = V_D = 0.1V$

If Q_2 – ON



KCL at node D:

$i_2 = i_{C_2} + i_2'$

$\boxed{i_{C_2} = i_2 - i_2'}$

$i_2 = \dfrac{V_{CC} - V_D}{R_{C_2}}$

$i_2 = \dfrac{12 - 0.1}{2 \times 10^3} = \dfrac{11.9}{2} \times 10^{-3} = 5.95\,mA$

$i_2' = \dfrac{V_D - (-V_{BB})}{R_1 + R_2}$

$= \dfrac{0.1 + 12}{(47 + 10)K\Omega} = \dfrac{12.1}{57} \times 10$

$\boxed{i_2' = 0.21\,mA}$

$i_{C_2} = i_2 - i_2' = (5.95 - 0.21)mA$

www.Jntufastupdates.com Scanned by CamScanner

$i_{C_2} = 5.74\,mA$

$i_{C1} = 0$

$i_{B1} = 0$

$i_{B2} = 0.67\,mA$

$i_{B2} = ?$

Apply KCL at node B

$$i_1 = i_4 + i_{B2}$$

$$i_{B2} = i_1 - i_4$$

$$i_1 = \frac{V_{CC} - V_B}{R_{C_1} + R_1}$$

$$= \frac{12 - 0.7}{(12)\times 10^3}$$

$$i_1 = 0.94\,mA$$

$$i_4 = \frac{V_B - (-V_{BB})}{R_2}$$

$$i_4 = \frac{0.7 + 12}{47\times 10^3}$$

$$i_4 = 0.27\,mA$$

$$I_{B2} = I_1 - I_4$$

$$= (0.94 - 0.27)\,mA$$

$$I_{B2} = 0.67\,mA$$

www.Jntufastupdates.com Scanned by CamScanner

$$i_3 = \frac{V_A - (-V_{BB})}{R_2}$$

$$V_A = V_D - R_1(i_2')$$

$$= 0.1 - 10k\Omega(0.21mA)$$

$$\boxed{V_A = -1.9V}$$

$$i_3 = \frac{-1.9 + 12}{47 \times 10^3}$$

$$\boxed{i_3 = 0.2148\ mA}$$

$$i_1' = \frac{V_C - V_B}{R_1}$$

$$V_C = V_{CC} - i_1 R_{C1}$$

$$= 12 - 0.94mA(2 \times 10^3)$$

$$\boxed{V_C = 10.14\ V}$$

$$i_1' = \frac{10.14 - 0.7}{10 \times 10^3}$$

$$\boxed{i_1' = 0.94\ mA}$$

$$i_{E1} = 0,$$

$$i_{E2} = i_{C2} + i_{B2}$$

$$\boxed{i_{E2} = 6.41mA}$$

For Q_1 → i/p is V_A

$$\boxed{V_A = -1.9V}$$

∴ Q_1 remains off why because V_A is -Ve'.

www.Jntufastupdates.com Scanned by CamScanner

$Q_2 \rightarrow$ Base current

$i_{B2} = 0.671\,mA$

LOKT $i_{C2} = 5.7\,mA$

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

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

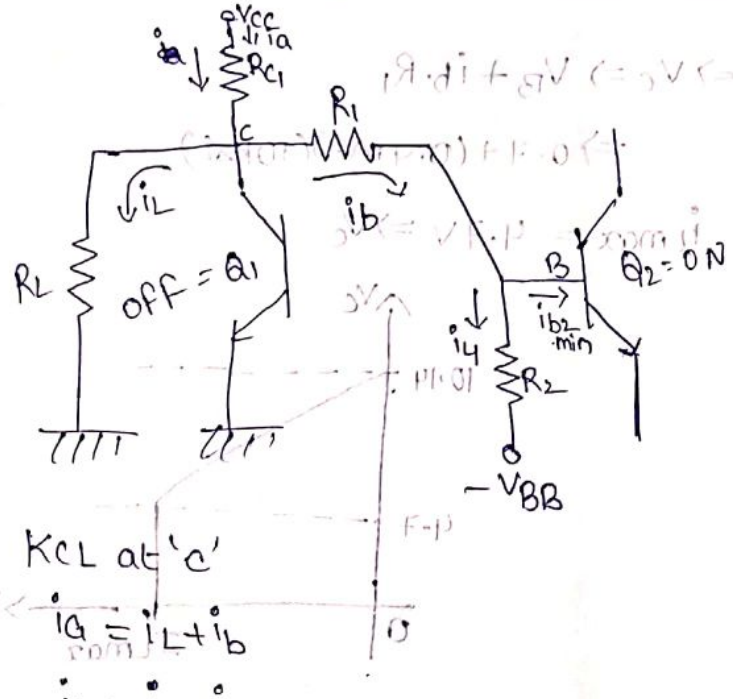
$$= \frac{5.7\,mA}{30}$$

$$\boxed{i_{B2\,min} = 0.19\,mA}$$

$i_{B2} > i_{B2\,min}$

$Q_2 - ON$

(c) To find $I_{L\,max}$



KCL at 'c'

$i_a = i_L + i_b$

$i_L = i_a - i_b$

$$i_a = \frac{V_{cc} - V_c}{R_{c1}}$$

$$i_a = \frac{12 - 10.14}{2 \times 10^3} = 0.93\,mA$$

www.Jntufastupdates.com Scanned by CamScanner

KCL at 'B':-

$$i_b = i_{b2min} + i_4$$

$$i_4 = \frac{V_B - (-V_{BB})}{R_2}$$

$$= \frac{0.7 + 12}{47K\Omega}$$

$$i_4 = 0.27\,mA$$

$$i_b = 0.19\,mA + 0.27\,mA$$

$$\boxed{i_b = 0.46\,mA}$$

$$i_L = i_a - i_b$$

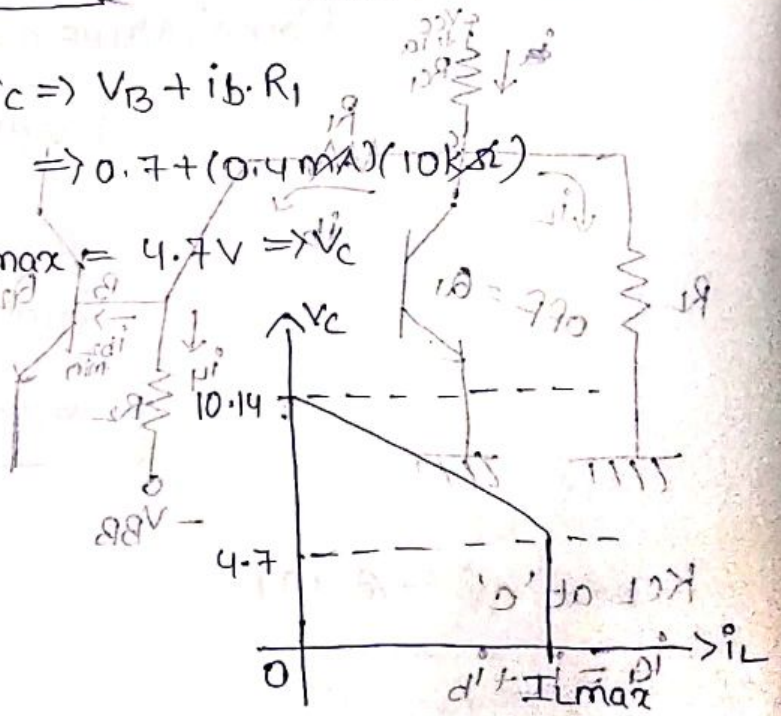
$$= (0.93 - 0.46)\,mA$$

$$\boxed{i_L = 0.47\,mA}$$

$$i_{Lmax} \Rightarrow V_C \Rightarrow V_B + i_b \cdot R_1$$

$$\Rightarrow 0.7 + (0.4\,mA)(10K\Omega)$$

$$i_{Lmax} = 4.7V \Rightarrow V_C$$



www.Jntufastupdates.com Scanned by CamScanner