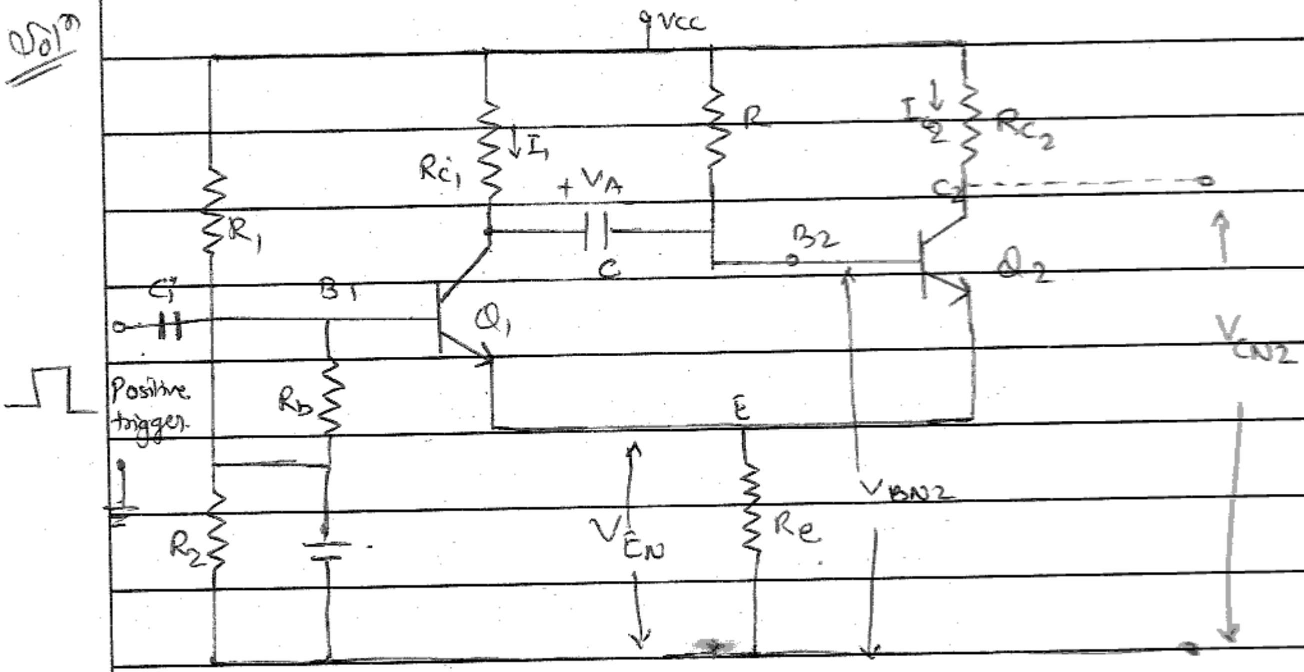
Unit-IV Part-B

Q1 Describe the circuit diagram of emitter Coupled Monostable Multivibrator and explain its Operation with relevant waveforms?

Sol^n



The emitter terminal of both the transistor are coupled together hence called emitter coupled. The Connection from Collector C_2 to the base B_1 is absent. The feedback is provided through a common emitter resistance Re. A negative supply is not required.

The input trigger is connected to terminal B_1 which is also not connected to any other point. Thus trigger input Source cannot load the circuit.

In collector coupled monoshot. I_1, controls the gate width T but it is not possible to maintain I_1 Stable. But in the emitter Coupled monoshot I_1 can be Stabilized with emitter resistance R_e. Hence perfect control of T with I_1 can be achieved. This is possible because when Q_2 goes OFF, Q_1 goes ON and operates with sufficient emitter resistance.

The I_1 inturn can be controlled by biasing V and it is observed that T varies linearily with V.

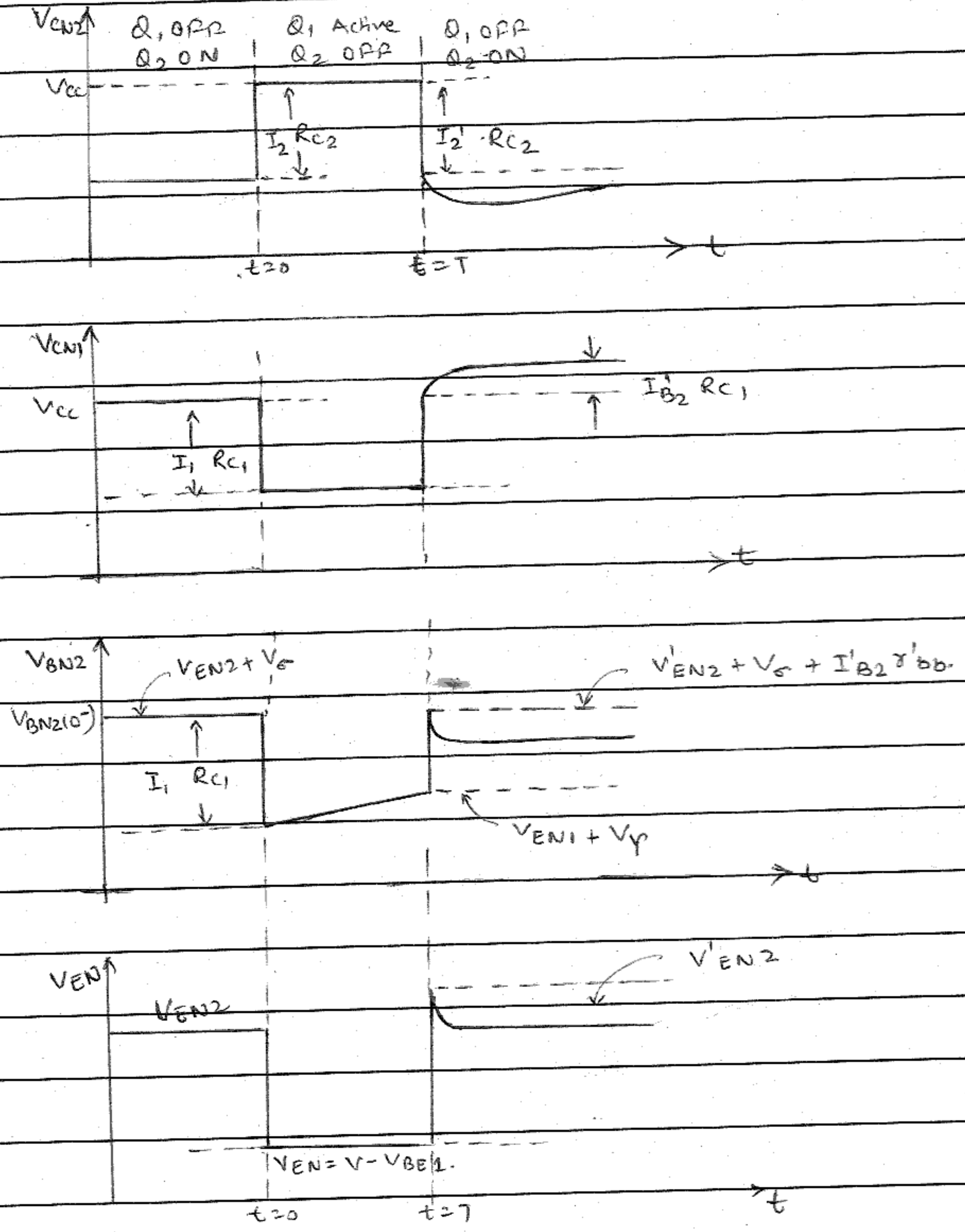
Waveforms:

The waveform at the emitter is more important in this monoshot. Consider the mode of operation with Q_1 cut-off and Q_2 in saturation in the stable state.

In the stable state Q_1 is OFF and Q_2 is ON. The Q_2 is in saturation. It derives base drive from Vcc and resistance R. Due to its emitter current it produce a voltage V_{EN2} across the resistance R_e. This voltage is more than the base potential of Q_1 which ensure that Q_1 remains OFF.

When the positive trigger is applied to the base of Q_1 then V_{B1} becomes more than V_{EN2} which drives Q_1 into conduction. Due to this, the collector voltage of Q_1 drops by $I_1 R_{C1}$. This negative step is applied to the base of Q_2 which makes Q_2 OFF. The capacitor C now charges through R from Vcc through ON Transistor Q_1. The ON Q_1 developes potential drop of V_{EN1} across R_e. This is the quasistable state with Q_1 ON and Q_2 OFF.

As the capacitor charges the base B_2 of Q_2 becomes more positive. When the potential V_{BN2}, becomes more than $V_{EN1} + V_\gamma$ then the transistor Q_2 starts conducting. Due to the regenerative feedback, Q_2 goes into saturation while Q_1 is cut-off. Thus the stable state with Q_1 OFF and Q_2 ON is achieved.



V_CN2
Q1 OFF
Q2 ON
Q1 Active
Q2 OFF
Q1 OFF
Q2 ON
Vcc
I2 RC2
I2' RC2
t=0
t=T
t
V_CN1
Vcc
I1 RC1
I'B2 RC1
t
V_BN2
V_EN2 + Vσ
V_BN2(0-)
I1 RC1
V'EN2 + Vσ + I'B2 r'bb.
VEN1 + Vγ
t
VEN
VEN2
V'EN2
VEN = V - VBE1.
t=0
t=T
t

* Extreme Limits of V.

In stable state Q_1 must be OFF. Hence there is a limit V_{max} for bias voltage V to be applied to base Q_1.

while when Q_1 is ON then $I_{C_1} R_{C_1}$ drop must be large so as to cut-off Q_2. This puts a minimum limit V_{min} for bias voltage V.

For Q_1 OFF in stable state, $V_{EN2} > V_{\gamma 1}$.

$$\boxed{V_{max} = V_{EN2} + V_{\gamma 1}} \quad \text{--- (1)}$$

while for having minm I_1 to cut off Q_2 in quasi-stable state V_{min} is given by.

$$V_{min} = (V_{EN1})_{min} + V_{BE1} \quad \text{--- (2)}$$

This Eqn (2) further be rearranged as.

$$\boxed{V_{min} = V_{BE1} + \frac{V_{BN2}(0^-) - V_{\gamma 2} + (R_{C_1}/R)(V_{CC} - V_{\gamma 2})}{1 + \left(\frac{R_{C_1}}{R}\right) + \left(\frac{R_{C_1}}{R_e}\right)\left[h_{FE}/(1+h_{FE})\right]}}$$

* Gate width of emitter coupled monoshot.

The expression of gate width can be derived using the basic relation

$$V_C = V_f + (V_i - V_f)\, e^{-t/\tau} \quad \text{--- (1)}$$

The voltage V_{BN2} just after trigger is applied is given by,

$$V_{BN2}(0^+) = V_{BN2}(0^-) - I_1 R_{C_1} \quad \text{--- (2)}$$

If Q_2 did not conduct, V_{BN2} would approach V_{CC}.

V_{BN2} = Instantaneous voltage at B_2.

$$V_{BN2} = V_{CC} - [V_{CC} - V_{BN2}(0^-) + I_1 R_{C_1}]\, e^{-t/\tau} \quad \text{--- (3)}$$

$$\text{where} \quad \tau = C(R + R_{C_1}) \quad \text{--- (4)}$$

At $t = T^-$, just before pulse ends.

$$V_{BN2} = V_{EN1} + V_{\gamma 2}$$

Equating (3) & (4)

$$V_{EN1} + V_{\gamma 2} = V_{CC} - [V_{CC} - V_{BN2}(0^-) + I_1 R_{C_1}]\, e^{-t/\tau}$$

Solving for T, the gate width is obtained as,

$$\boxed{T = \tau \ln \left\{ \frac{V_{CC} - V_{BN2}(0^-) + I_1 R_{C_1}}{V_{CC} - V_{EN1} - V_{\gamma 2}} \right\}}$$

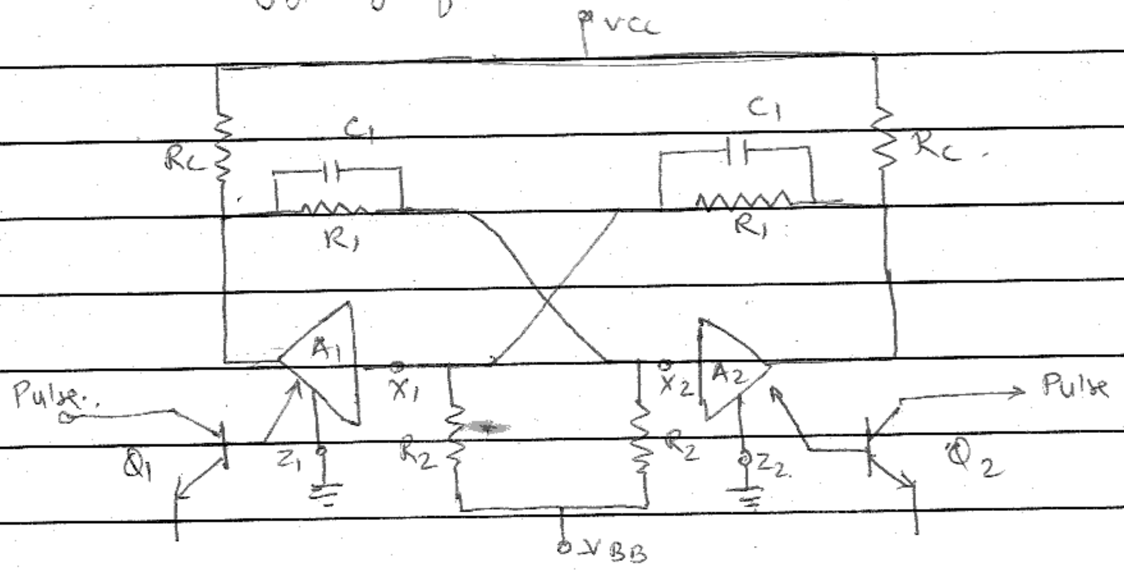
Q2 Explain the unsymmetrical and symmetrical triggering of bistable Multivibrator

Sol^n

Unsymmetrical Triggering:

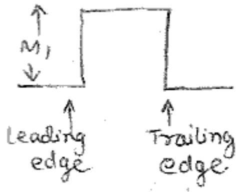
In unsymmetrical triggering, two trigger inputs are used one to set the circuit in one particular Stable State and other to reset the circuit to the opposite State.

Unsymmetrical Triggering of Bistal Multivibrator:—

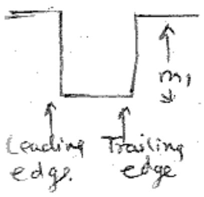


The device A_1 and A_2 are the n-pn transistor. Let A_1 is OFF and to turn it ON positive step is applied to the base of A_1 through C_1. But to have the transition of A_1 from OFF to ON, such a positive pulse is required which must exceed the voltage by which the transistor is below cut-off. Hence achieving transition by making a transistor ON from OFF is difficult. As against this now if negative step is applied to the input of A_2 which is ON ~~from~~ ~~OFF~~ will immediately decreaces the current through it. Then A_2 starts Operating in active region from saturation region.

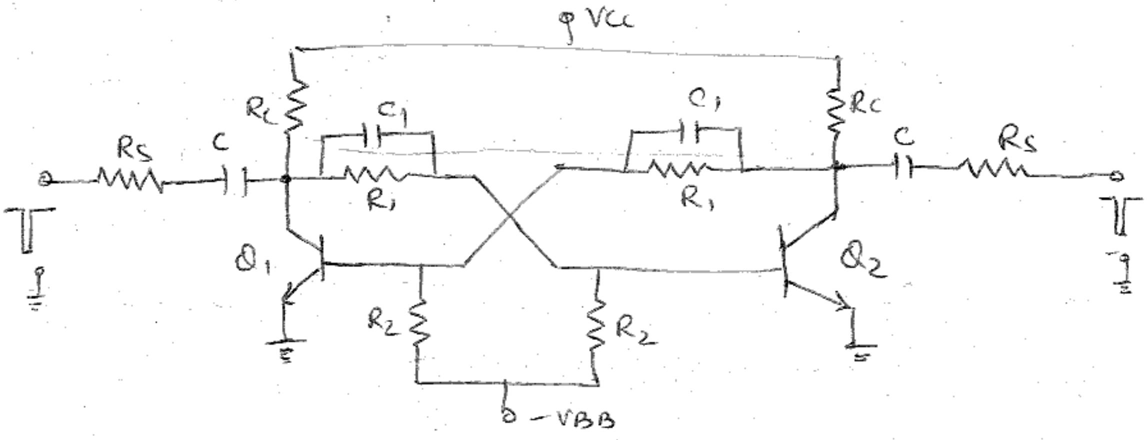
Hence input voltage at X_2 gets amplified at Y_2 and part of it gets applied to X_1 which is base of OFF transistor A_1. Then the regenerative action takes place due to increase in current through A_1 and circuit completes the transition. This shows that small negative step applied to ON transistor is enough to cause the transistion. Hence binary circuit is more sensitive to transition due to switching ON transistor OFF rather than making OFF transistor ON.



Another difficulty in making OFF transistor ON is related to the use of positive pulse as shown in the fig. If such a pulse is applied to OFF transistor and if amplitude M_1 is more than the voltage by which OFF transistor is below cut off, then the transisition occurs and OFF and transistor becomes ON.



But if negative pulse is applied to make ON transistor OFF then its magnitude M_1 at leading edge can be adjusted small to which circuit transistion result. But same M_1 which the voltage by which OFF transistor is below cut off and reverse transition can not occur at trailing edge.

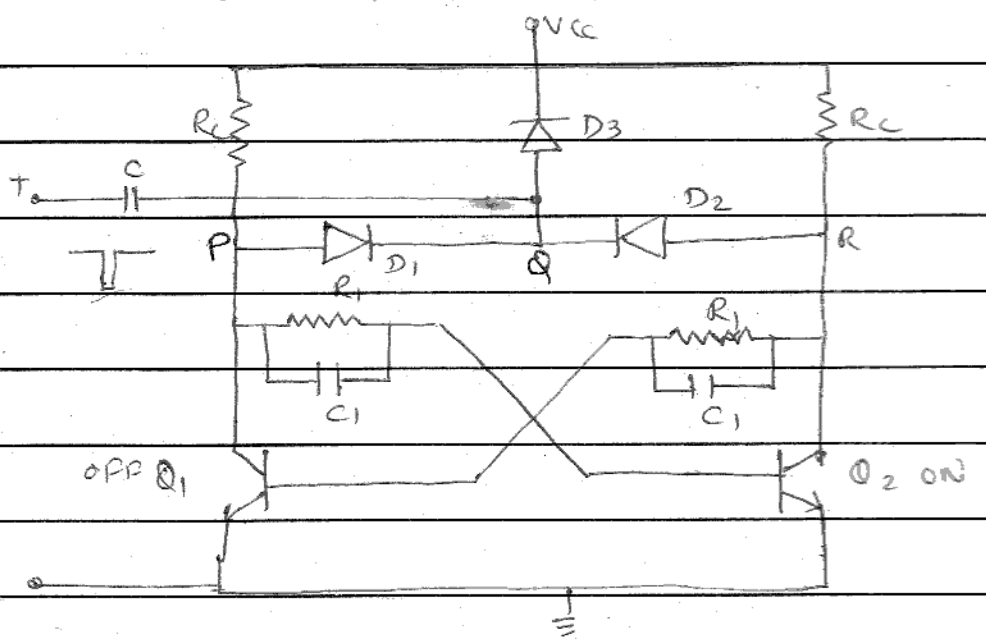


Let Q_2 is ON and Q_1 is OFF. So negative pulse is applied to the point A i.e at output of Q_1. The signal immediately appears at the base i/p X_2 of the Q_2. This is due to the transmission through commutating capacitor C_1. The presence of series resistance R_S further increases the sensitivity of npn transistor to a negative pulse. This quickly turns OFF Q_2 and turn ON Q_1. It is necessary that R_S must be large, in series with C. To have next transition, a second triggering signal is required at Y_2 which quickly appears at the base of Q_1. This turns OFF Q_1 and makes Q_2 ON. Thus two separate triggering source are reqd. to apply pulses at two different points to achieve a transition of state. Thus it is an unsymmetrical Triggering.

* Symmetrical triggering :-

Symmetrical trigger uses only one trigger input to the input of any one transistor.

Symmetrical triggering of Bistable circuit :-



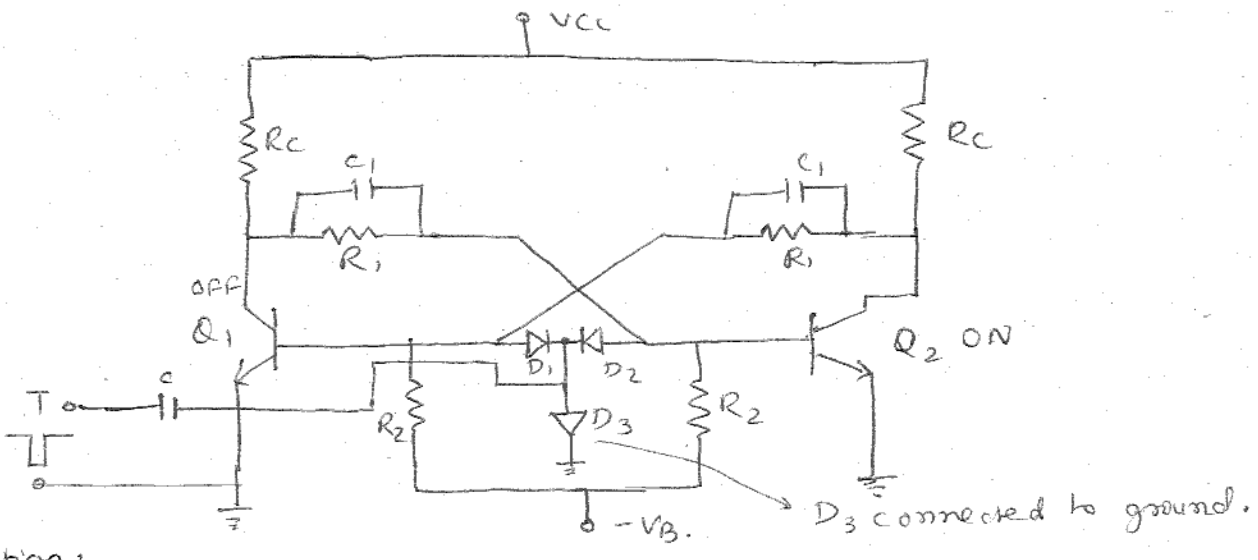
Assume the Q_2 is ON and Q_1 is OFF. Hence the drop across Rc of Q_2 is large and due to which D_2 is reverse biased. The Q_1 is OFF hence there is no voltage drop across Rc of Q_1. Hence points P and Q are equipotential i.e. at Vcc and drop across D_1 is zero. This keeps diode D_1 at zero bias.

When negative going pulse is applied at the triggering i/p T, the point Q goes negative, due to which D_1 gets forward biased. It acts as a short circuit hence pulse reaches to point p which is collector of Q_1. Then the negative pulse is passed to the base of Q_2 through R_1 and C_1. This puls switches OFF the transistor Q_2 and Q_1 becomes ON. Then transition of bistable occur. After the transistion D_1 bec reverse biased while D_2 is maintained at zero bias.

When next triggering negative pulse is applied then again point Q goes negative due to which D_2 becomes forw biased and pulse is passed to the point R. From this gets applied to the base of Q_1 through R_1 and C_1. This tu off Q_1 and turn ON Q_2. This transistion occur. Hence for each triggering pulse the transistion of bistable result The diodes D_1 and D_2 are called steering diodes. The ckt will not respond to the +ve pulse.

If the pulse rate is low then the Diode D_3 can be repla by a resistance R. Similarly if the pulse amplitude is small the a ckt with triggering amplifier can be used.

The Symmetrical triggering using Diodes can be used to apply trigger to the base i/p of transistor, as shown in fig.



Application: Unsymmetrical

1> Used in logic circuitry such as registers and coding ckt

Symmetrical

1> Binary Counting ckt

Q3 Draw the circuit diagram of complementary transistor monostable multivibrator and explain its operation.

Soln

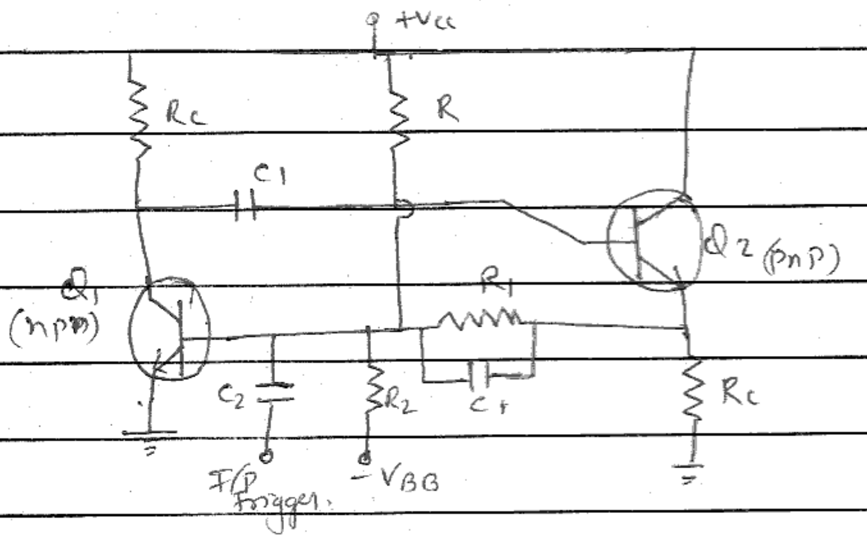
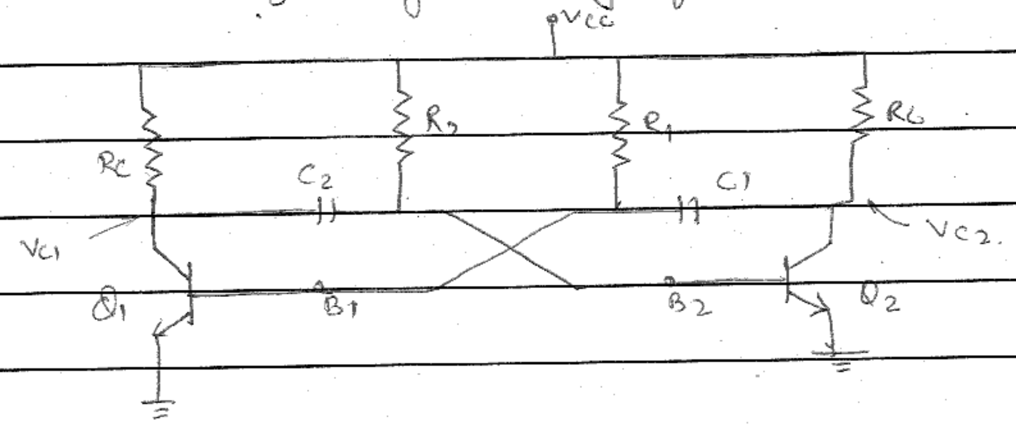


Fig complementary monostable multivi

Q4 Describe the performance of collector coupled astable multivibrator with relevant diagram.

Soln

A astable Multivibrator has two states, both are quasi-stable. None of the states is stable. And without external trigger multivibrator keeps on alternating the states. It cannot remain indefinitely in any of these two states.



The Q_1 and Q_2 are identical npn transistors. The two collector resistances are equal to R_C. The collector Q_1 is coupled to the base of Q_2 through capacitor C_2 while the collector of Q_2 is coupled to the base of Q_1 through capacitor C_1. The capacitive coupling is used between the stages due to which neither transistor can remain permanently cut-off.

At start to understand the working, assume that the state is Q_2 ON and Q_1 OFF. The capacitor C_2 starts charging towards Vcc through path R_C, C_2 and ON Q_2. Thus finally voltage across C_2 becomes equal to Vcc with proper polarity.

At the same time capacitor C_1 which is charged to Vcc in the earlier state, starts discharging through path Q_2

V_{CC}, R_1, C_1. The paths for charging of C_2 and discharging of C_1 are shown in fig (a) & (b)

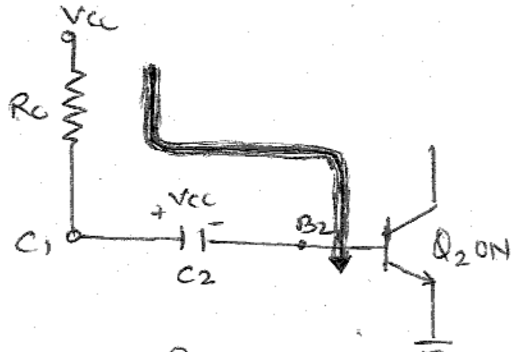


Fig (a)

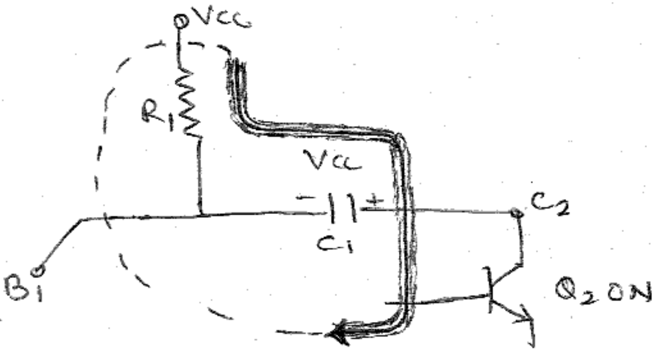
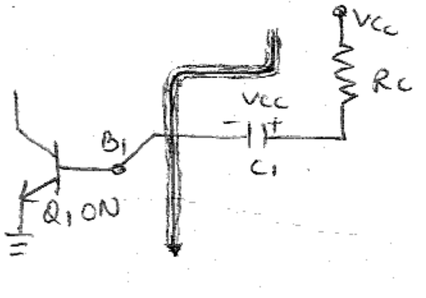
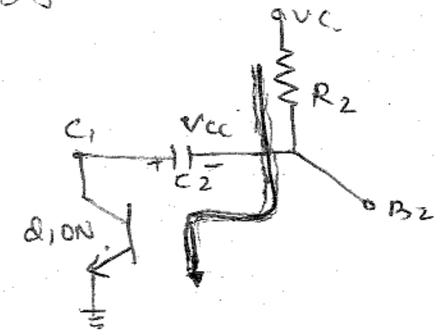


Fig (b)

The base of Q_1 is at $-V_{CC}$ at the begning. But as C_1 starts discharging it becomes less and less negative i.e becomes more positive. Finally it becomes equal to V_γ, the cut in voltage of transistor Q_1. When it becomes just greater than V_γ, the transistor Q_1 starts conducting. So Q_1 becomes ON and at the same time Q_2 becomes OFF. The negative potential applied at B_2 due to charged C_2 ensure that Q_2 becomes indeed OFF.

When this happens, the capacitor C_1 starts charging again through R_C, C_1 and ON transistor Q_1. While C_2 starts discharging through the path V_{CC}, R_2, C_2 and ON transistor Q_1. Both the paths are shown in fig (c)(d)



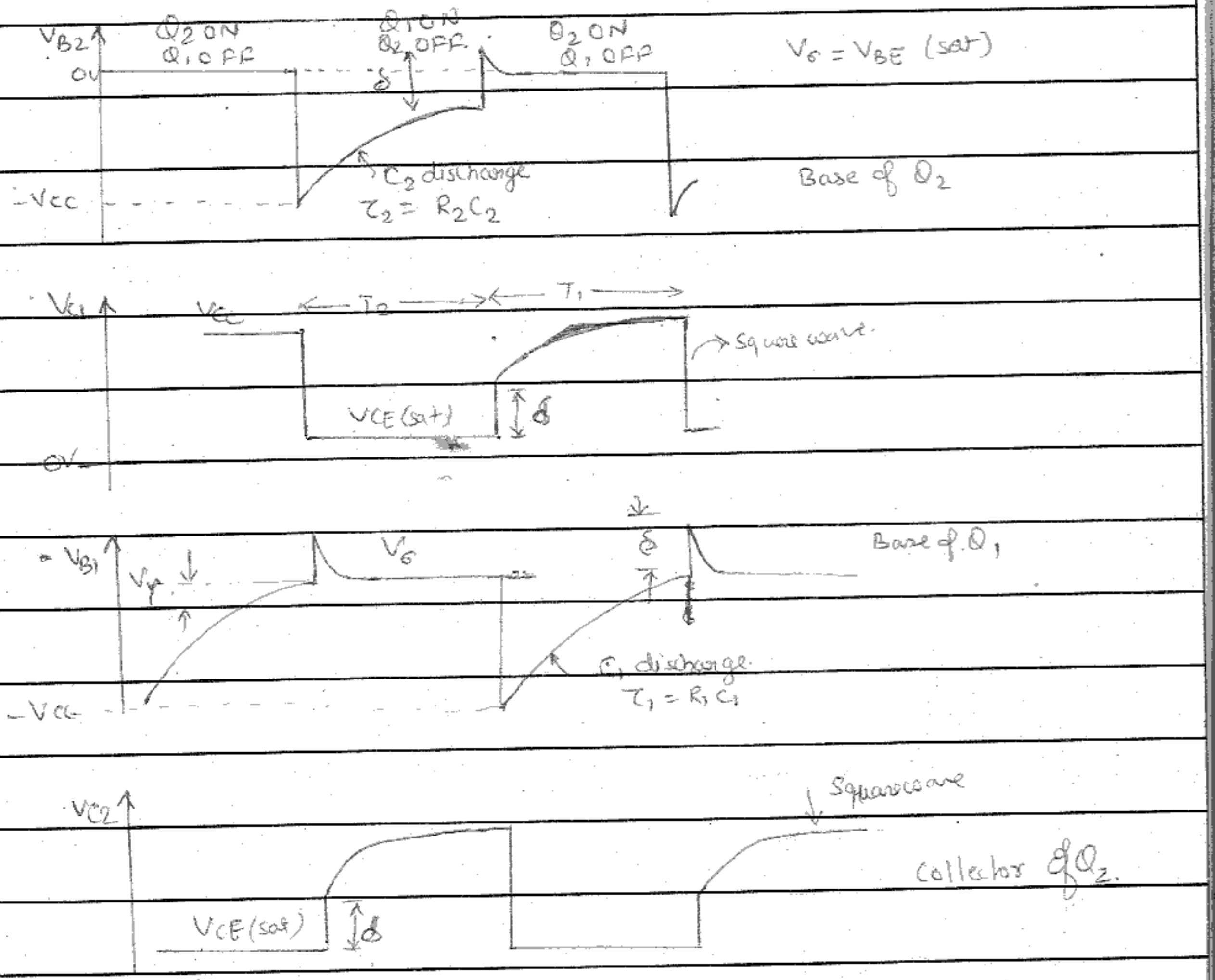


As C_2 discharges, B_2 potential becomes less negative i.e. it increases towards positive when V_{B2} becomes just greater than cut in voltage V_γ of Q_2 the Q_2 starts conducting. Thus now Q_2 becomes ON and Q_1 OFF. Thus the change in the two states is automatic and without any external triggering signal.

* Waveforms of Astable Multivibrator.

Waveform at the collectors of Q_1 and Q_2 is OFF and Q_2 is ON, the C_1 discharge and voltage at B_1 ie V_{B1} increases. This increases exponentially with the time constant R_1C_1. This voltage was initially at $-V_{CC}$ when this voltage increases beyond cut in voltage of Q_1, Q_1 starts conducting when Q_1 is in saturation.

$V_{B1} = V_{BE(sat)}$, $V_{C1} = V_{CE(sat)}$ $V_{C2} = V_{CC}$



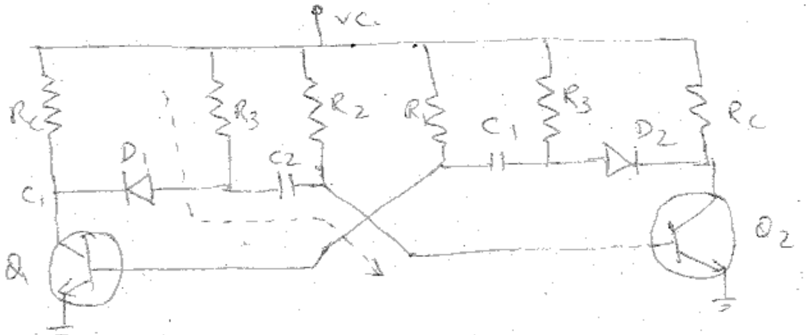
When Q_1 is ON and Q_2 is OFF, the C_2 discharges and voltage at B_2 i.e. V_{B2} increases. This increases exponentially with the time constant R_2C_2. This voltage was initially at $-V_{CC}$ in the previous state. When this voltage increases beyond cut in voltage of Q_2, Q_2 conducts and goes in saturation.

$V_{B2} = V_{BE(sat)}$, $V_{C2} = V_{CE(sat)}$; $V_{C1} = V_{CC}$.

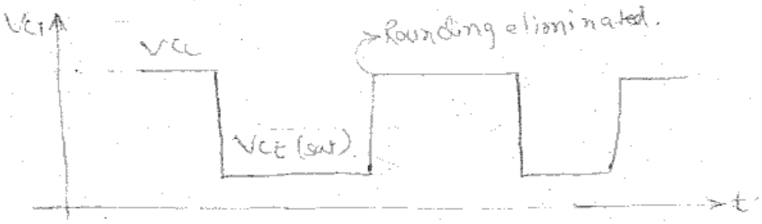
Distortion and its Elimination.

It can be seen that, in the collector waveforms shown in the fig. there is certain distortion present. Instead of exact square wave, we are getting the vertical rising edges little bit rounded. This is called rounding. For square wave o/p. Such a rounding is undesirable. and must be eliminated.

Such a rounding can be eliminated to obtain the vertical edge square wave by adding two collector diodes and two resistor. The collector coupled astable multivibrator with collector diodes and auxiliary resistors is shown.



If Q_1 is off then its collector voltage increases suddenly to V thus making D_1 reverse biased. Thus the charging of C_2 now takes place through R_3 rather than R_C. As current doesnot flow through R_C, the collector voltage can rise suddenly to Vcc and the rounding at the collector completely gets eliminated.



5 With a neat Diagram explain the operation of Schmitt trigger circuit.

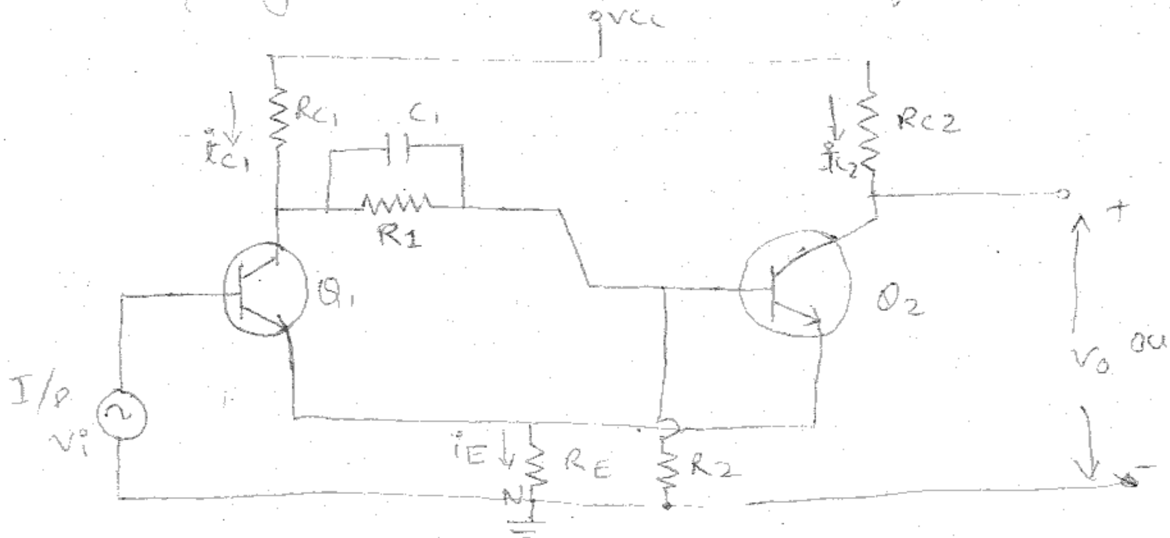


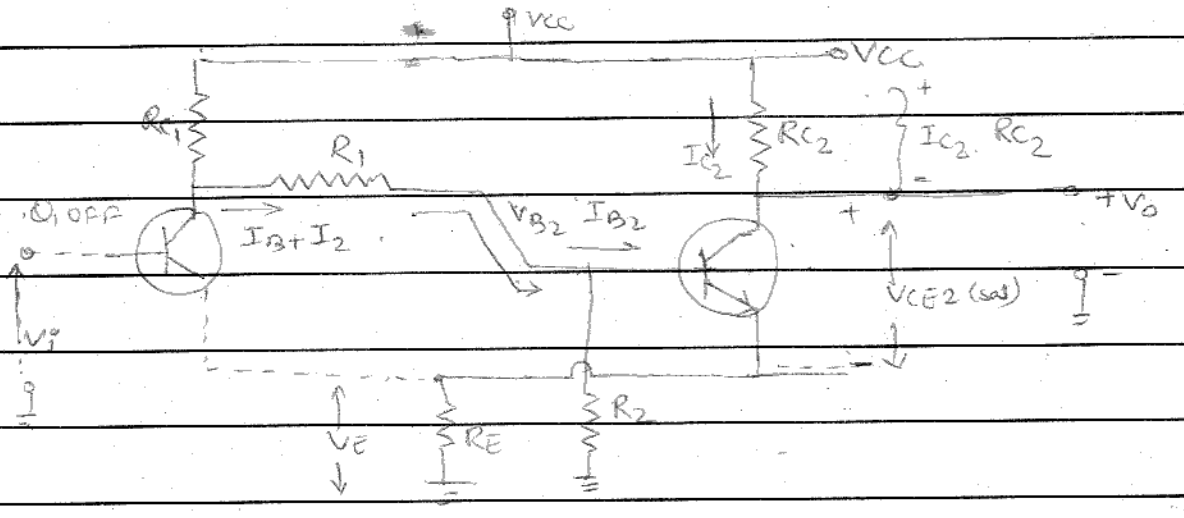
Fig shows an important bistable circuit. It looks basic bistable conf. but it differs by the fact that the coupling from collector of the transistor Q_2 to the input of the first stage is missing in this circuit.

The emitter of the two transistors are connected to each other and grounded through the resistance R_E.

The feedback is obtained through the resistance R_E. This circuit is called Schmitt trigger circuit. There exists two stable states of the output of this circuit.

* **Operation of the Circuit:-**

Assume that a sinusoidal input voltage V_i is applied to the circuit. Let transistor Q_2 is conducting and is saturated. And as $V_i = 0$ at start Q_1 is cut-off. When Q_1 is OFF, it can be treated as open circuit thus circuit reduces.



Now. V_{B2} = Drop across R_2

This can be obtained by potential divider formed by R_{C1}, R_1 and R_2 across Vcc $\therefore V_{B2} = I_2 R_2$

Thus current I_{C2} flows through Q_2 hence

$$V_o = V_{CC} - I_{C2} R_2 \quad \text{——— (1)}$$

Now when V_i is increasing and to make Q_1 ON, it ~~must increase to the~~ level equal to cutin voltage V_{BE1} of Q_1 ~~…~~ plus the amount by which emitter voltage is raised i.e. V_E. So when V_i reaches to $V_{BE1} + V_E$ the Q_1 gets driven to active region. This input voltage is called upper threshold point (UTP) of the Schmitt trigger. It is also input turn-on threshold level.

- As Q_1 is ON, i_{C_1} starts flowing. Due to drop across R_{C1} the base voltage of Q_2 reduces. This cumulatively reduces V_E which help Q_1 to conduct heavily and finally Q_1 gets driven into saturation. And simultaneously Q_2 is cut-off. At this point the output voltage is approximately V_{CC}. The cumulative action is very fast and switch over the output from its initial level of $V_{CC} - i_{C2} R_{C2}$ to V_{CC} is almost instantaneous. So we get fast rising output pulse when V_i reaches to UTP level. Then input looses the control over output and output remains in the stable state of V_{CC}. This level will not change automatically.

When Q_1 is ON, Q_2 is OFF acts as open circuit. This condition is shown in the fig.

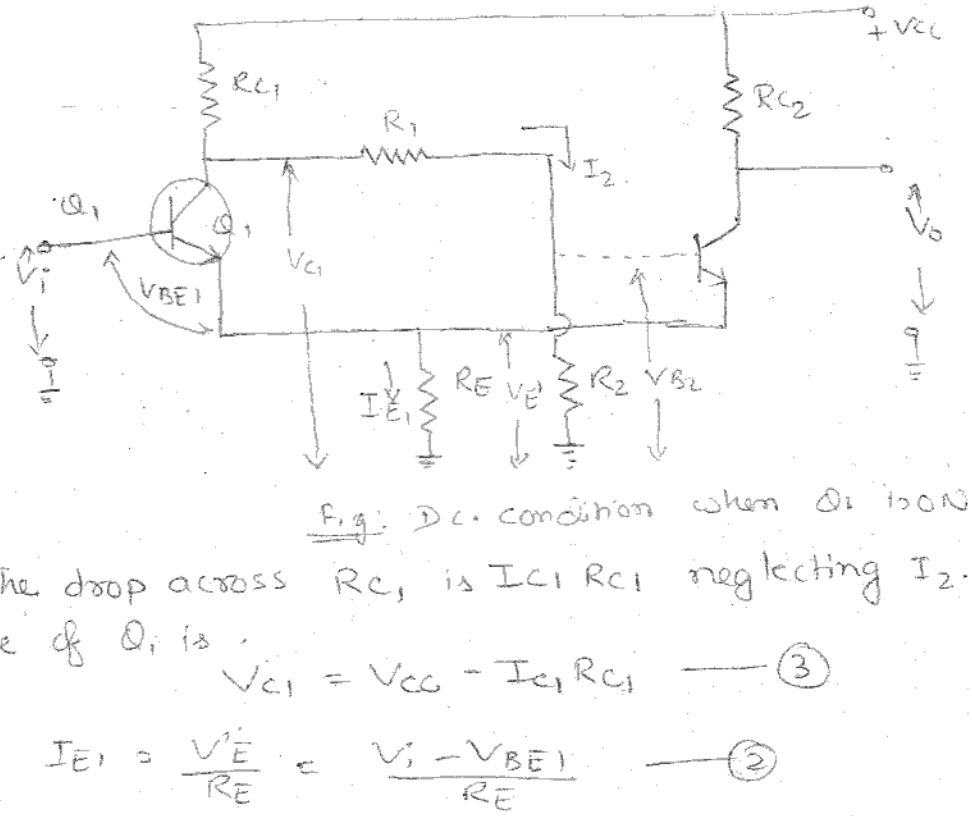


Fig: D.C. condition when Q_1 is ON

The drop across R_{C1} is $I_{C1} R_{C1}$ neglecting I_2. Hence the collector voltage of Q_1 is.

$$V_{C1} = V_{CC} - I_{C1} R_{C1} \quad \text{——} (3)$$

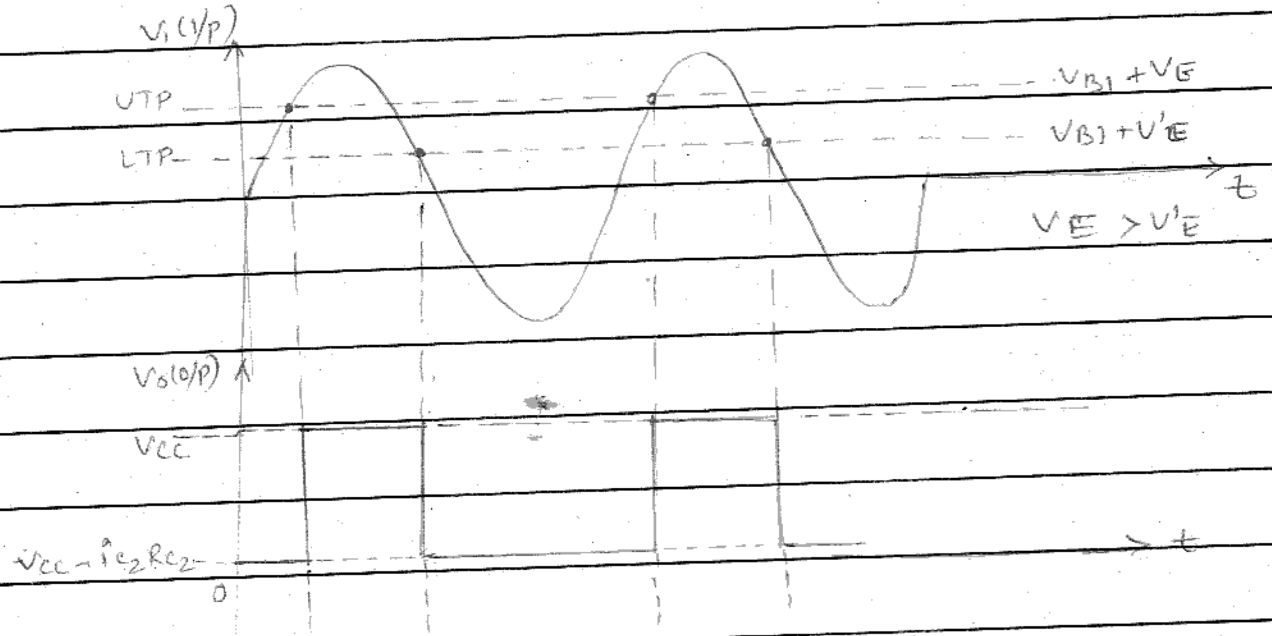
$$\therefore \; I_{E1} = \frac{V'_E}{R_E} = \frac{V_i - V_{BE1}}{R_E} \quad \text{——} (2)$$

Thus I_{C1} reduces then V_{C1} increases, this directly controls V_{B2} of Q_2 which also increases. Thus when V_i starts decreasing and becom[es] equal to V_{B2} then Q_2 again becomes ON. The level of V_i at which Q_2 again becomes ON is called lower threshold point (LTP) of the

Schmitt Trigger.

This is another stable state of the output and input loses control on output. The switchover from V_{cc} to $V_{cc} - i_{C2} R_{C2}$ is again instantaneous at LTP. So output remains at lower level till V_i reaches to the UTP.

The output has two stable states. So the circuit can be used as a voltage comparator to provide a change in output whenever the input exceeds a particular desired value.



* Hysteresis :- The graph of output voltage against input voltage is called transfer characteristics of the Schmitt trigger.

It can be observed that once output changes its state it remain there indefinitely until the input voltage crosses any of the threshold levels. So when output changes its state from low to high at UTP, it remains there till input crosses LTP and vice-versa. This characteristics of Schmitt trigger is called hysteresis. It is also dead band or dead zone as there is no change in o/p in this zone though input changes

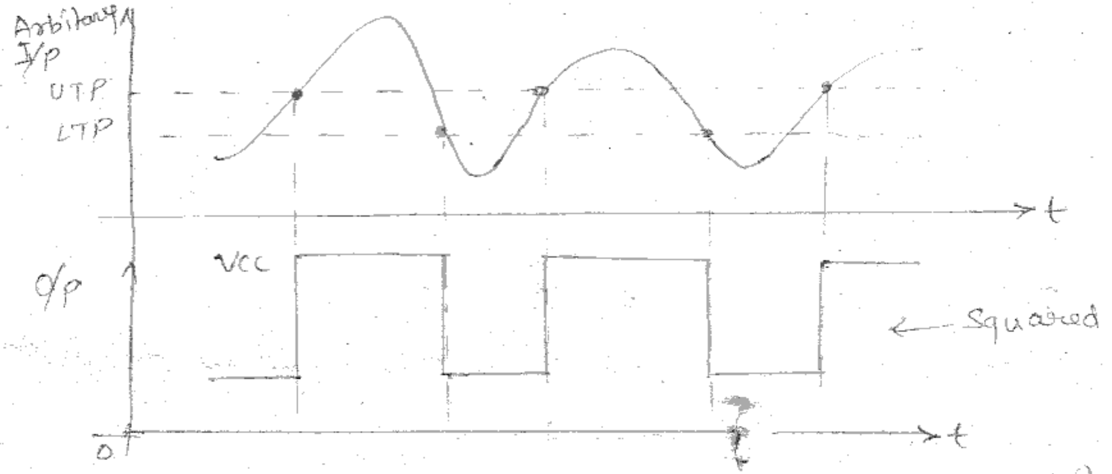
The loop of this characteristics is called hysteresis loop. The difference b/w UTP and LTP is called the width of hysterisis.

$$\therefore \boxed{w = \text{width of hysteresis} = UTP - LTP}$$

The amount of hysteris can be changed by changing the value of R_{C1} and R_{C2}. While the UTP can be increased by increasing the value of R_E

* **Applications:**

An important application of the Schmitt trigger is its use as an amplitude comparator. It identifies the moment at which any arbitrary waveform attains a particular reference level.



It can be used as a Squaring circuit. Any arbitary i/p can be converted to a square wave, using schmitt trigger. Schmitt trigger can be used as flip-flop which is its another application.