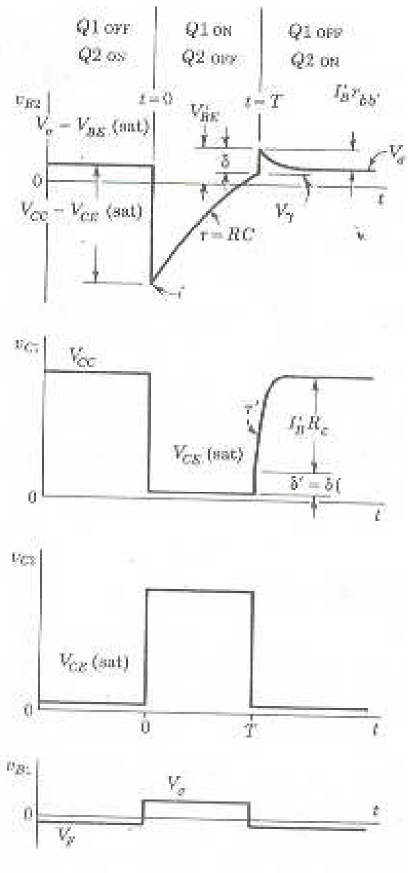
Waveforms of the Monostable Multivibrator:

We shall now explain the waveforms at both collectors and bases. Assume that the triggering signal is applied at t=0 and the reverse transition occurs at t = T. so here monostable is in its quasistable state for a time T.

The stable state:



for t<0 , Q1 OFF & Q2 ON ,

Here $v_{C1} = V_{CC}, v_{C2} = V_{CE(sat)}, v_{B2} = V_{BE(sat)}$

And $v_{B1} = \frac{-V_{BB}R_1}{R_1 + R_2} + \frac{V_{CE(sat)}R_2}{R_1 + R_2} = V_F$

(by applying superposition principle at base terminal of Q1)

The Quasi stable state:

As a result of trigger applied at t=0 ,

Q2 goes OFF and Q1 conducts.

So the voltages v_{C1} and v_{B2} drop abruptly by the same amount $I_1 R_C$, where I_1 is the current in R_C of Q1. since voltage across the capacitor C can not changes instantaneously.

Under these circumstances

$v_{C1} = V_{CE(sat)}, v_{B1} = V_{BE(sat)}$ and $I_1 R_C = V_{CC} - V_{CE(sat)}$

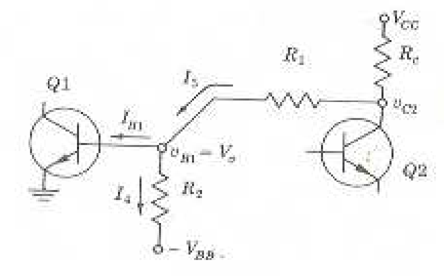
Base circuit of Q1 when Q1 is in ON state is shown below,

By using the principle of superposition,

$$v_{C2} = v_{C2} due to V_{CC} + v_{C2} due to V_{BE(sat)}$$

$$v_{C2}\, due to V_{CC} = \frac{V_{CC} R_1}{R_1 + R_C}$$

$$v_{C2}\, due to V_{BE(sat)} = \frac{V_{BE(sat)} R_C}{R_1 + R_C}$$



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

The voltage at the base of Q2 now starts to rise exponentially toward V_{CC} with a time Constant $\tau = RC$ (by neglecting R_O). until v_{B2} reaches the cutin voltage V_γ at t = T

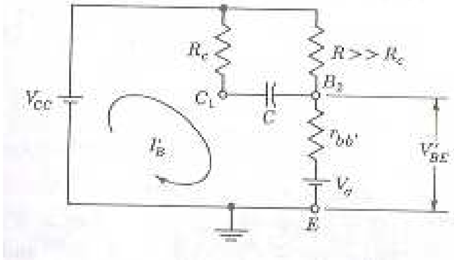
All voltages at the other transistor terminals remain unalterd.

Waveforms for t >T:

At t = T+ , Q2conducts and Q1 is cutoff. The collector voltage v_{C2} drops abruptly to $V_{CE(sat)}$ and v_{B1} returns to V_F. The voltage v_{C1} now rises abruptly , since Q1 is OFF. This increase in voltage is transmitted to the base of Q2 and drives Q2 heavily into Saturation. Hence , an overshoot develops in v_{B2} at t = T+ which decays as the Capacitor C recharges (reaches its initial voltage) because of the base current.
We shall now calculate the magnitude of this overshoot.

The base current may be accounted for adequately by replacing the input circuit of Q2 By the base-spreading resistance $r_{bb'}$ in series with the base saturation voltage $V_{BE(sat)}$, as indicated in the above waveforms. The base current at t = T+ is designated By $I_B{}'$. The current in R may usually be neglected compared with $I_B{}'$.

The path of $I_B{}'$ as shown in figure below.



From this figure we see that

$$V'_{BE} = I_B{}' r_{bb'} + V_{BE(sat)} \text{ and } V_{C1} = V_{CC} - I_B{}' R_c$$

From the above waveforms the jumps

In voltage at B_2 and C_1 are, respectively,

$$\delta = I_B^{'} r_{bb'} + V_{BE(sat)} - V_\gamma \text{ and } \delta' = V_{CC} - I_B^{'} R_c - V_{CE(sat)}$$

Since C_1 and B_2 are connected by a capacitor , these two discontinuous voltage

Changes must be equal. From the relationship $\delta = \delta'$ we obtain

$$I_B^{'} = \frac{V_{CC} - V_{CE(sat)} - V_{BE(sat)} + V_\gamma}{R_c + r_{bb'}}$$

From the above circuit , the time constant with which v_{B2} and v_{C1} decay to their

Steady state values is $\tau' = (R_c + r_{bb'})C$.

Expression for Gate width (or) Pulse width of Monostable Multi:

Consider T is the gate width of monostablemulti .

From the waveforms below , we know that voltage at base terminal of Q2 varies

Exponentially.

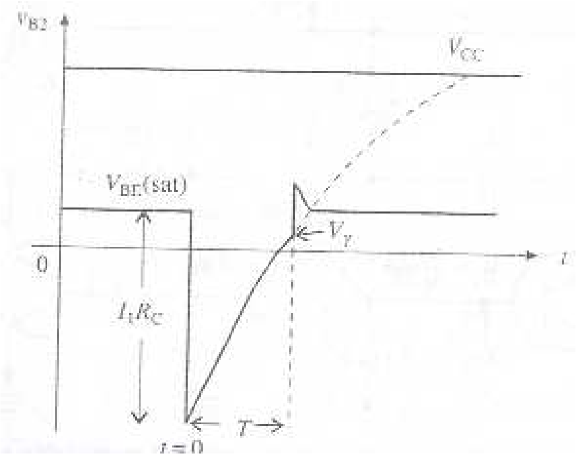
General expression for exponential signal is $v_O = v_f + (v_i - v_f)e^{-\frac{(t-t_x)}{\tau}}$

Here $t_x = 0$, $v_f = V_{CC}, v_i = V_{BE(sat)} - V_{CC} + V_{CE(sat)}$

$\tau = RC$ and at $t = T, v_O = V_\gamma$

Then $V_\gamma = V_{CC} + \left(V_{BE(sat)} + V_{CE(sat)} - 2V_{CC}\right)e^{-\frac{T}{RC}}$

$$e^{-\frac{T}{RC}} = \frac{V_\gamma - V_{CC}}{V_{BE(sat)} + V_{CE(sat)} - 2V_{CC}}$$



By taking natural logarithm ,

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

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

But from the typical values , $V_{BE(sat)} + V_{CE(sat)} = 2V_\gamma$

So $T = RC\ln\left(\frac{2V_\gamma - 2V_{CC}}{V_\gamma - V_{CC}}\right)$

$$T = RC\ln(2) = 0.693\ \text{RC}$$