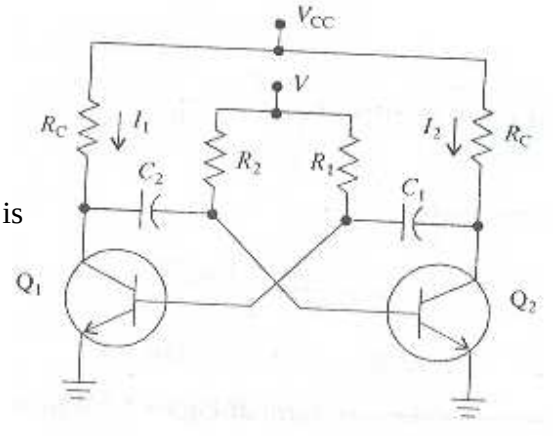
Astable multivibrator as a voltage to frequency converter:

We know for astable , If $R_1 = R_2 = R and C_1 = C_2 = C$ then $T = 1.386RC$

The frequency of oscillations may be varied over the range from cycles to megacycles Per second by adjusting R or C. It is possible to change T, electrically by connecting R_1 and R_2 to an auxiliary voltage V (the collector supply remains V_{CC}) as shown in figure.

In this circuit diagram , capacitors(voltage at base terminals) will tries to charge towards V instead of $V_{CC.}$



General expression for exponential signal is

$$v_O = v_f + (v_i - v_f)e^{-\frac{(t-t_x)}{\tau}}$$

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

$\tau = RC$ and at $t = T_1, v_O = V_\gamma$

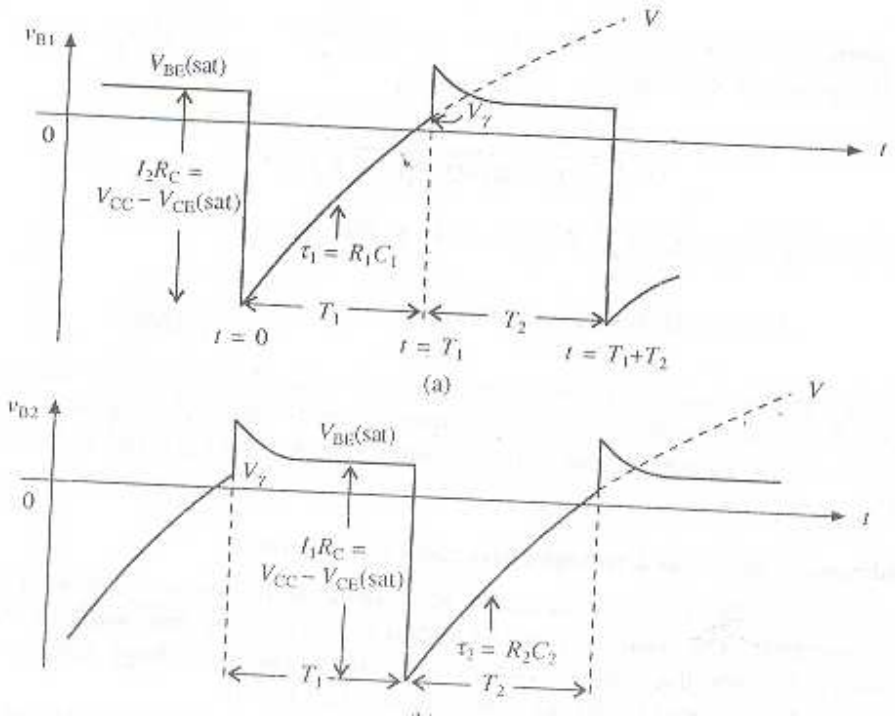
Then

$$V_\gamma = V + \left(V_{BE(sat)} + V_{CE(sat)} - V_{CC} - V\right)e^{-\frac{T_1}{RC}}$$

$$e^{-\frac{T_1}{RC}} = \frac{V_\gamma - V}{V_{BE(sat)} + V_{CE(sat)} - V_{CC} - V}$$

By taking natural logarithm ,

$$-\frac{T_1}{RC} = \ln\left(\frac{V_\gamma - V}{V_{BE(sat)} + V_{CE(sat)} - V_{CC} - V}\right)$$



$$T_1 = RC\ln\left(\frac{V_{BE(sat)} + V_{CE(sat)} - V_{CC} - V}{V_\gamma - V}\right)$$

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

So $$T_1 = RC\ln\left(\frac{V_{CC} + V}{V}\right)$$

$$T_1 = RC\ln\left(1 + \frac{V_{CC}}{V}\right) = T_2$$

So $T = T_1 + T_2$

$$T = 2RC\ln\left(1 + \frac{V_{CC}}{V}\right)$$

$$f = \frac{1}{2RC\ln\left(1 + \frac{V_{CC}}{V}\right)}$$

This shows that by varying V , the frequency f can be varied .