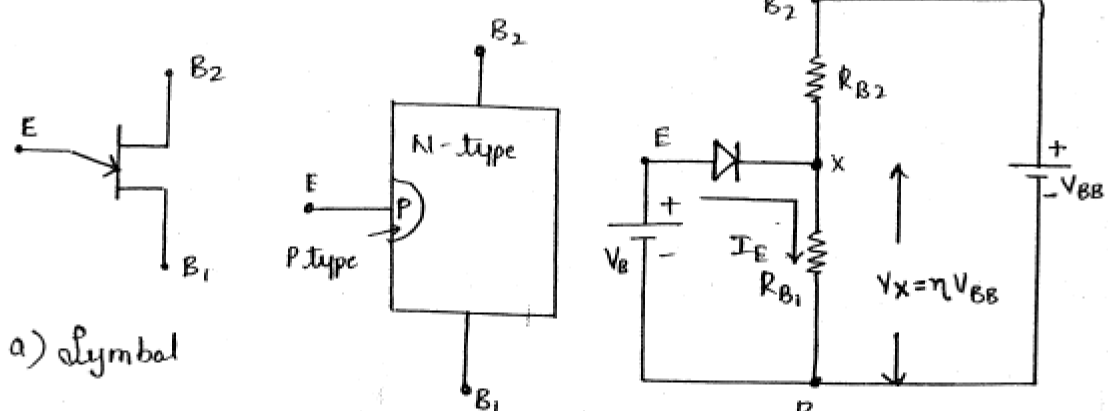
❖ **UNIJUNCTION Transistor :-**

* The drawback with R - firing & RC - firing is that power dissipation in the gate ckt is more. to overcom this drawback , UJT firing ckt is used.

* UJT is an abbrevation for unijunction transistor made up of n type silicon material to which P-type emitter is fixed

UJT has 3 terminals namely Emitter (E) Base - 1 (B1) & Base - 2 (B2)



a) Symbol
b) Structure
c) Equivalent ckt.

* R_{B1} & R_{B2} are the internal resistance respectively from Bases B_1 & B_2 to x - point.

When a voltage V_{BB} is applied across the two base terminals B_1 & B_2 , the potential of point x wrt B_1 is given by

$$V_x = I R_{B1}$$

$$= \frac{V_{BB}}{R_{B1} + R_{B2}} \cdot R_{B1}$$

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

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

where $\eta = \frac{R_{B1}}{R_{B1} + R_{B2}}$

* $R_{BB} = R_{B1} + R_{B2}$ $\therefore \eta = \frac{R_{B1}}{R_{BB}}$.

Where η is the internal UJT vtg divider ratio & is called the intrinsic stand off ratio.

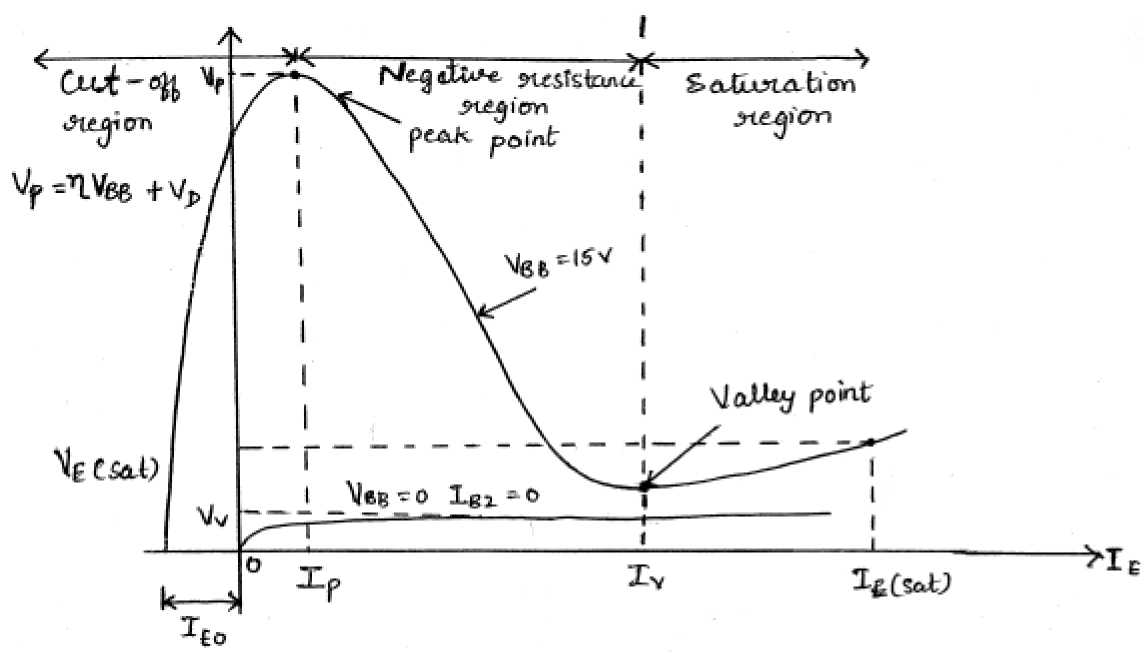


fig :- Characteristics for $V_{BB} = 0$ & $V_{BB} = 15V$.

The characteristics can be divided into three main regions

1) <u>Cut-off region</u> :-

When the emitter valtage V_E is less than V_P, the p-n junction is reverse biased. A small amount of reverse saturation current I_{EO} flows through the device.

2) <u>Negetive resistance region</u>:-

When the emitter voltage V_E becomes equal to V_P, the p-n junction becomes forward biased and I_E starts flowing. The voltage across the device decreases in this region, though the current through the devices increases. Hence the region is called negetive resistance region. This decreases the resistance R_{B1}. This region continues till valley point.

3) <u>Saturation region</u>:-

The further increase in the 'I_E' beyond the valley point current 'I_V' drives the device in the saturation region. The voltage corresponding to the valley point is called Valley point voltage denoted as V_V.

❖ UJT-Relaxation oscillator :-

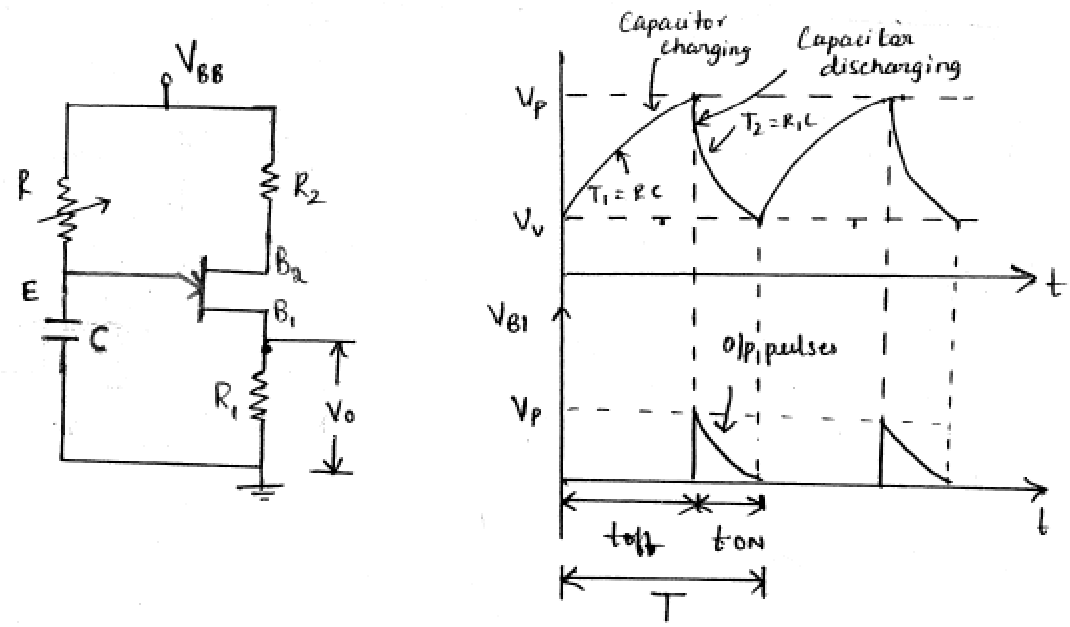


Fig ① shows a UJT relaxation oscillator.

When dc supply 'V_{BB}' is applied, Capacitor 'C' begins to charge through R exponentially toward V_{BB}. During this charging, emitter ckt of UJT is an open ckt

* The control Vtg $V_C = V_E$ is given by

$$V_C = V_E = V_{BB}(1 - e^{-t/RC})$$

* The charging time constant is given by

$$\boxed{\tau_1 = RC}$$

* When this emitter voltage $V_E = V_C$ reaches the peak point vtg $V_P = \eta V_{BB} + V_D$, the UJT turns ON & Capacitor 'C' discharges through low resistance R_1.

* The discharging time constant is given by

$$\boxed{\tau_2 = R_1 C}$$

Hence τ_2 is much smaller than τ_1

* When discharging vtg dropped to 'V_V', UJT turns OFF. The charging & discharging process of capacitor repeats for each period T & is given by

$$T = RC \ln\left(\frac{1}{1-\eta}\right)$$

* R_2 is used for thermal stability of V_P, the value of R_2 can be calculated by using formula.

$$R_2 = \frac{10^4}{\eta V_{BB}}$$

* The maximum value of R is determined by

$$R_{max} = \frac{V_{BB} - V_P}{I_P} = \frac{V_{BB} - (\eta V_{BB} + V_D)}{I_P}$$

The minimum value of R is given by

$$R_{min} = \frac{V_{BB} - V_V}{I_V}$$

* R_1 can be calculated as

$$\boxed{R_1 = \frac{V_{BB}}{\text{leakage current}} - R_2 - R_{B1} - R_{B2}}$$

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Derive the expression for Periodic time 'T' of the UJT relaxation oscillator

Soln:- The voltage across the Capacitor is given by

$$V_P = V_{BB}(1 - e^{-t/RC})$$

When $V_P = \eta V_{BB} + V_D$, the capacitor will discharge through R_1

Substituting 'V_P' value in eq ①, we get

$$\eta V_{BB} + V_D = V_{BB}(1 - e^{-t/RC})$$

Since $V_{BB} >> V_D$, neglecting V_D

$$\eta V_{BB} = V_{BB}(1 - e^{-t/RC})$$

$$\eta = 1 - e^{-t/RC}$$

$$e^{-t/RC} = 1 - \eta$$

$$\frac{1}{e^{-t/RC}} = \frac{1}{1-\eta}$$

$$e^{t/RC} = \frac{1}{1-\eta}$$

Taking $\log_e$ on both side we get

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

put $\boxed{t = T}$ is above equation

$$\boxed{T = RC \log_e\left(\frac{1}{1-\eta}\right)}$$

The frequency of oscillation 'f'

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

$$\boxed{f = \frac{1}{RC \log_e\left(\frac{1}{1-\eta}\right)}}$$

PROBLEMS

1) A UJT is used to trigger the thyristor whose minimum gate triggering voltage is 6.2V, the UJT ratings are : η=0.66, I_p=3mA, I_v =0.5mA, $R_{B1}+R_{B2}$ = 5KΩ, leakage current = 3.2mA, V_p=14V and V_v=1V. Oscillator frequency is 2KHz and capacitor C=0.04μf. Design the complete circuit.

<u>Soln</u> :- Assume $V_D = 0.8V$

$$T = \frac{1}{f} = \frac{1}{2 \times 10^3}$$

WKT $T = RC \ln\left(\frac{1}{1-\eta}\right)$

$$\frac{1}{2\times 10^3} = R \times 0.04\mu F \left(\frac{1}{1-0.66}\right)$$

$$\boxed{R = 11.6 K\Omega}$$

* The peak voltage is given by

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

$$V_{BB} = \frac{V_p - V_D}{\eta} = \frac{14V - 0.8V}{0.66}$$

$$\boxed{V_{BB} = 20V}$$

* $$R_2 = \frac{0.7(R_{B1} + R_{B2})}{\eta V_{BB}} = \frac{0.7(5\times 10^3)}{0.66 \times 20}$$

$$\boxed{R_2 = 265.15\Omega}$$

* $V_{BB} = I_{leakage} (R_1 + R_2 + R_{B1} + R_{B2})$

$$20V = 3.2 \times 10^{-3} (R_1 + 265 + 5 \times 10^3)$$

$$\frac{20V}{3.2 \times 10^{-3}} = R_1 + 5.265\,k\Omega$$

$$R_1 = 625 - 5.265\,k\Omega$$

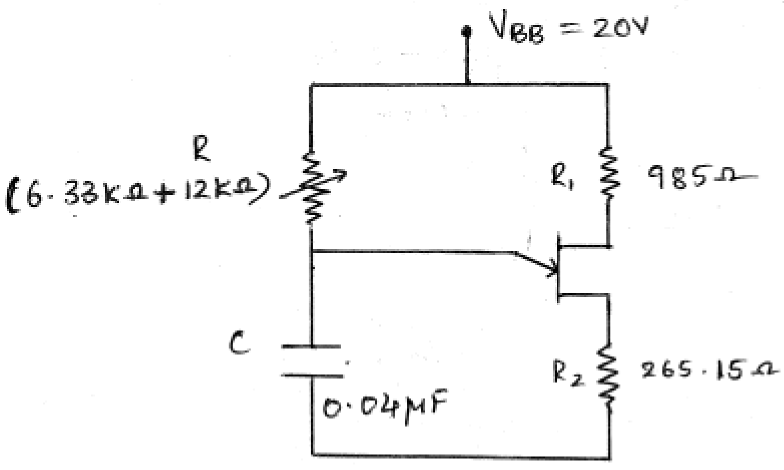
$$\boxed{R_1 = 985\,\Omega}$$

* $R_{(max)} = \frac{V_{BB} - V_P}{I_P} = \frac{20V - 14V}{0.5 \times 10^{-3}}$

$$\boxed{R_{(max)} = 12K\Omega}$$

* $R_{(min)} = \frac{V_{BB} - V_V}{I_V} = \frac{20V - 1V}{3 \times 10^{-3}}$

$$\boxed{R_{(min)} = 6.33\,K\Omega}$$



2) Design the UJT triggering circuit for SCR. Given V_{BB}=20V, η=0.6, I_P=10A, V_V=2V, I_V=10mA. The frequency of oscillation is 100HZ. The triggering pulse width should be 50μsec.

Given :- $V_{BB} = 20V$, $\eta = 0.6$, $I_p = 10\mu A$, $V_v = 2V$,

$I_v = 10mA$, $f = 100 Hz$, $\tau_2 = 50\mu sec$.

Soln :- $T = \frac{1}{f} = \frac{1}{100Hz}$

WKT $T = RC \ln\left(\frac{1}{1-\eta}\right)$

$$\frac{1}{100} = RC \ln\left(\frac{1}{1-0.6}\right)$$

$$RC = 0.0109135$$

Assuming $C = 1\mu F$

$$R = \frac{0.0109135}{1\mu F}$$

$$\boxed{R_C = 10.91K\Omega}$$

* Peak Voltage

$$V_p = \eta V_{BB} + V_D$$ (Take $V_D = 0.8V$)

$$= 0.6 \times 20V + 0.8V$$

$$\boxed{V_p = 12.8V}$$

* $R_{(min)} = \frac{V_{BB} - V_v}{I_v} = \frac{20V - 2V}{10 \times 10^{-3}}$

$$\boxed{R_{(min)} = 1.8K\Omega}$$

* $R_2 = \frac{10^4}{\eta V_{BB}} = \frac{10^4}{0.6 \times 20}$

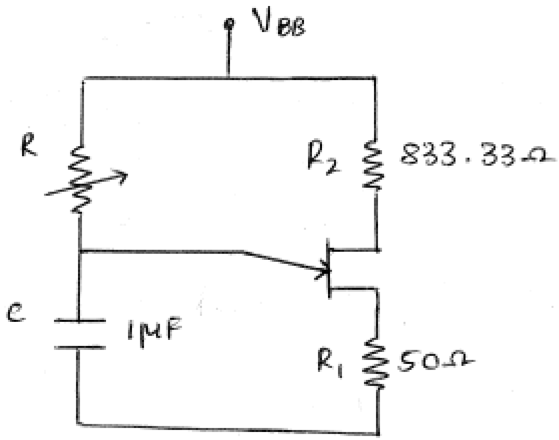
$$\boxed{R_2 = 833.33\,\Omega}$$

* The given pulse width $\tau_2 = 50\mu sec$

WKT $\tau_2 = R_1 C$

$$R_1 = \frac{\tau_2}{C_1} = \frac{50\mu sec}{1\mu F}$$

$$\boxed{R_1 = 50\,\Omega}$$



3) An UJT used in a relaxation oscillator circuit is having η=0.7, V_V=1V and the supply voltage to the circuit is 15V. Design the suitable values of R and C given that the frequency of oscillation is 1KHz. Peak current is 1mA and valley current is 8mA.

Sol Given :- $V_{BB} = 15V$, $\eta = 0.7V$, $V_v = 1V$, $f = 1KH_z$,

$I_P = 1mA$, $I_V = 8mA$

Assume $V_D = 0.8V$

Soln :- Peak Voltage

$$V_P = \eta V_{BB} + V_D$$

$$= 0.7 \times 15V + 0.8V$$

$$\boxed{V_P = 11.3V}$$

* The period of oscillation

$$T = RC \ln\left(\frac{1}{1-\eta}\right)$$

$$\frac{1}{1KH_z} = RC \ln\left(\frac{1}{1-0.7}\right)$$

$$RC = 8.3058 \times 10^{-4}$$

Assume $C = 1\mu F$

$$R = \frac{8.3058 \times 10^{-4}}{1\mu F}$$

$$\boxed{R = 830.58\Omega}$$

* $$R_{(max)} = \frac{V_{BB} - V_P}{I_P} = \frac{15V - 11.3V}{1 \times 10^{-3}}$$

$$\boxed{R_{(max)} = 3700\Omega}$$

* $$R_{(min)} = \frac{V_{BB} - V_V}{I_V} = \frac{15V - 1V}{8 \times 10^{-3}}$$

$$\boxed{R_{(min)} = 1750\Omega}$$