# Uni-Junction Transistor (UJT)
# Lecture – 3

## TDC PART – I
## Paper – I (Group – B)
## Chapter - 8

**by:**

**Dr. Niraj Kumar,**

**Assistant Professor (Guest Faculty)**

**Department of Electronics**

**L.S College, BRA Bihar University, Muzaffarpur.**

# (4) Theory of UJT Operation

- Initially imagine that the emitter supply voltage is turned down to zero then $V_E$ is zero. Then the intrinsic stand-off voltage, reverse-biases the emitter diode. If $V_D$ is the barrier voltage of the emitter diode, hence some reverse current $I_E$ flows until, the value of $V_E$ reaches a point at which

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

- This is the point where the curve touches the Y-axis then the total reverse bias voltage $V_E$ is

$$V_E = V_A + V_D$$

- When $V_{BB}$ is switched on, $V_A$ is developed and ***reverse-biases the junction***. If (**silicon diode forward voltage drop**) $V_D$ is the barrier voltage of the **P-N junction**, then total reverse bias voltage is

$$V_E = V_A + V_D$$

From equation (5) $V_A = \eta V_{BB}$, then we get

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

Value of $V_D$ for **Si** is **0.7 V**.

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

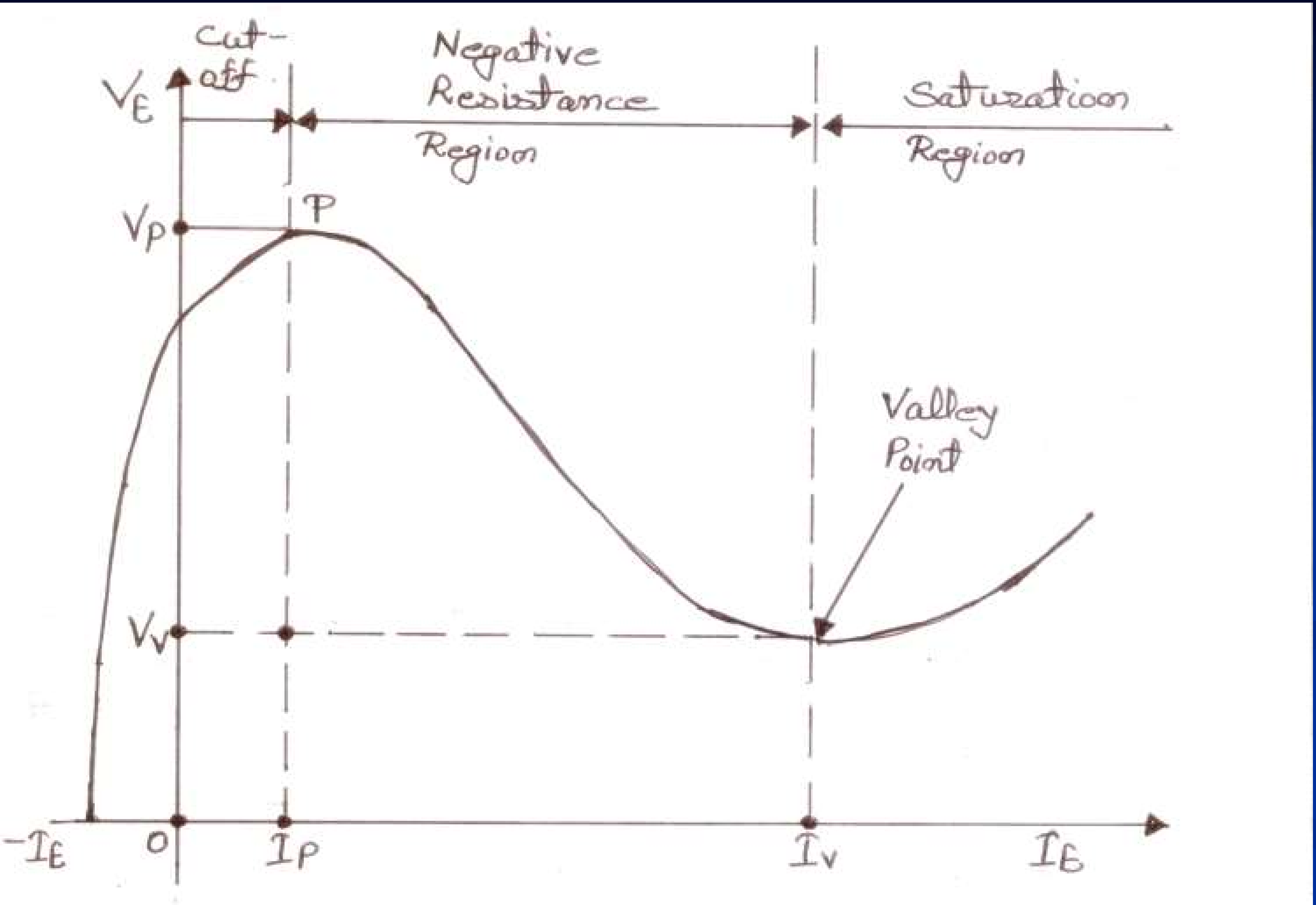
$$V_E = \eta V_{BB} + 0.7V$$

- It is obvious that emitter junction will not become forward-biased unless its applied voltage $V_E$ exceeds

$$V_E = (\eta V_{BB} + V_D) \text{ or}$$

$$V_E = \eta V_{BB} + 0.7V$$

- This value of $V_E$ is called **peak-point voltage $V_P$** which is **shown in Fig. (7) and (8).** When $V_E = V_P$, emitter (peak current), $I_P$ starts to flow through $R_{B1}$ to ground (*i.e.* $B_1$). The UJT is then said to have been **Fired** or **Turned ON.** Due to the flow of $I_E$ ($= I_P$) through $R_{B1}$, number of charge carriers in $R_{B1}$ is increased which **reduces its resistance.** As $\eta$ depends on $R_{B1}$, **its value is also decreased.**




- **Fig. (8)** Shown V-I Characteristics of UJT with Negative Resistance.

- Hence, we find that as $V_E$ and hence $I_E$ **increases** (beyond $I_P$), $R_{B1}$ decreases, $\eta$ decreases and $V_A$ decreases. This decrease in $V_A$ causes more emitter current to flow which causes a further reduction in $R_{B1}$, $\eta$ and $V_A$. Obviously, the process is **regenerative**, $V_A$ as well as $V_E$ quickly drop as $I_E$ increases. Since, $V_E$ decreases when $I_E$ increases, the **UJT Possesses Negative Resistance.** Beyond the valley point $V_V$, **UJT** is in **Saturation Region** and $V_E$ increases very little with an increasing $I_E$. It is seen that only terminals **E** and $B_1$ are the active terminals whereas $B_2$ is the bias terminal *i.e.* it is meant only for applying external voltage across the **UJT**.

- Generally, **UJT** is triggered into conduction by applying a suitable positive pulse at its **Emitter Terminal E.** It can be brought back to **OFF** state by applying a **negative trigger pulse**. Three other important parameters for the **UJT** are **$I_P$, $V_V$** and **$I_V$** and are defined below:

**(1) Peak-Point Emitter Current ($I_P$) :-** It is the emitter current at the peak point. It represents the minimum current that is required to trigger the device (UJT). It is inversely proportional to the inter-base voltage **$V_{BB}$**.

**(2) Valley Point Voltage ($V_V$) :-** The valley point voltage is the emitter voltage at the valley point. The valley voltage increases with the increase in inter-base voltage **$V_{BB}$**.

**(3) Valley Point Current ($I_V$) :-** The valley point current is the emitter current at the valley point. It increases with the increase in inter-base voltage **$V_{BB}$**.

# (5) Special Features of UJT

- The special features of a UJT are:-

**(1)** A stable triggering voltage **(VP)**

**(2)** Highly Stable Reliable Operation

**(3)** Low Power Consumption

**(4)** Easily Accessible and Cheap

**(5)** A very low value of triggering current.

**(6)** A high pulse current capability.

**(7)** A negative resistance characteristic.

(8) Low cost.

# (6) Advantage of UJT

**(1)** It is a Low cost device. The low cost per unit, combined with its unique characteristic, have warranted its use in a wide variety of applications.

**(2)** It has excellent Negative Resistance characteristics.

**(3)** UJT device has-a unique characteristic that when it is triggered, its emitter current increases re generatively (due to negative resistance characteristic) until it is restricted by emitter power supply.

**(4)** It is a low-power absorbing device under normal operating conditions.

# (7) UJT Applications

- One unique property of UJT is that it can be triggered by (or an output can be taken from) **any one of its three terminals.** Once triggered, the emitter current $I_E$ of the UJT increases **regeneratively** (**By Regenerative Process**) tills it reaches a limiting value determined by the external power supply.

- UJTs are most prominently used as relaxation oscillators. They are also used in Phase Control Circuits. In addition, UJTs are widely used to provide clock for digital circuits, timing control for various devices, controlled firing in thyristors, and sync pulsed for horizontal deflection circuits in CRO.

- Because of this particular behaviour, UJT is used in a variety of circuit applications. Some of which are:

1) Phase control
2) Switching
3) Pulse generation,
4) Sine wave generator
5) To generate non sinusoidal oscillations.
6) Sawtooth generator
7) Timing and trigger circuits,
8) Voltage or current regulated supplies.
9) It can be used as trigger device for SCR's and TRIAC's.
10) UJT widely used in electronic beepers, SMPS, inverters,blinkers,
11) UJT widely used in voltage controlled oscillators.

# (8) UJT Application as a Relaxation Oscillator

- An oscillator is a device that produces a waveform by its own, without any input. Though some dc voltage is applied for the device to work, it will not produce any waveform as input. A relaxation oscillator is a device that produces a non-sinusoidal waveform on its own. This waveform depends generally upon the charging and discharging time constants of a capacitor in the circuit. This non-sinusoidal waveform produced by UJT Relaxation Oscillator also known as Sawtooth waveform.

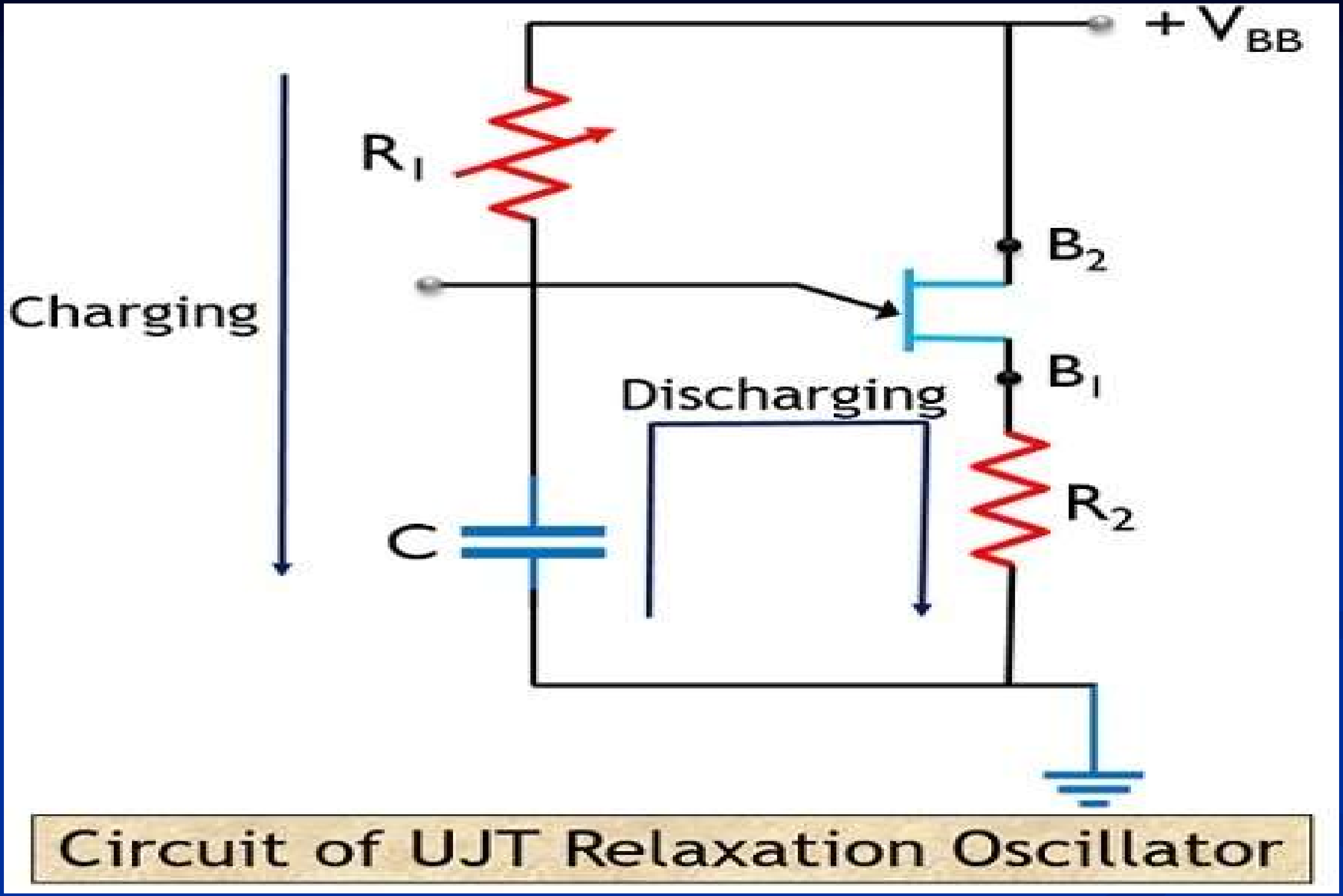
# Construction and Working

- The **emitter E**of UJT is connected with a **resistor R1** and **capacitor C** as shown in Fig (9) below. The **R1C time constant** determines the timings of the output waveform of the relaxation oscillator. Here the bases **B1** are connected with a resistor **R2** The **dc voltage supply VBB** is given. The **fig (9**) which is shown in next slide, shows how to use a UJT as a relaxation oscillator.

- Initially, the voltage across the **capacitor C** is zero.

  $V_C = 0$

- The UJT is in **OFF condition**. The **resistor R1** provides a path for the **capacitor C** to charge through the voltage applied.



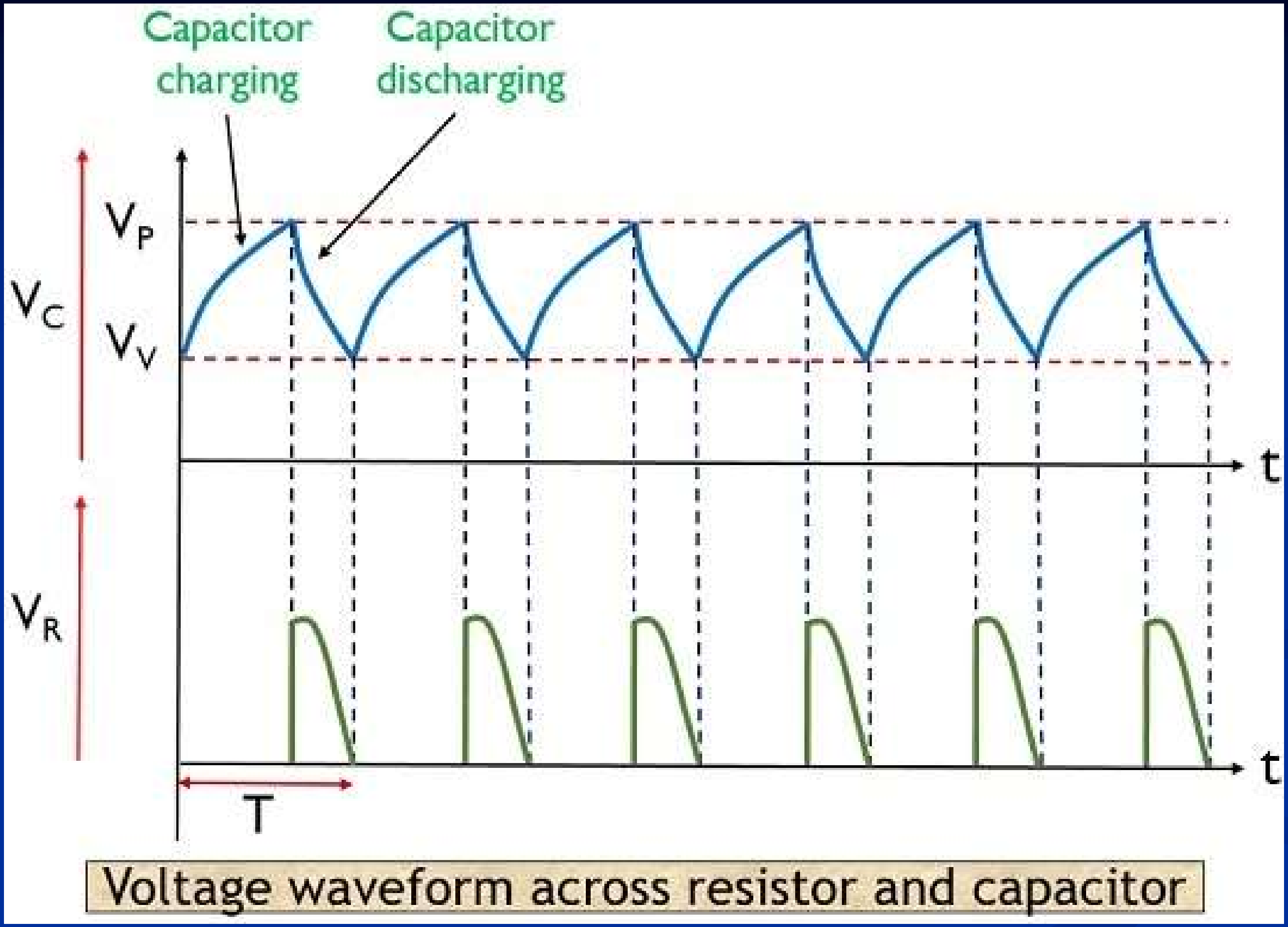

- **Fig (9)** Shown a Uni-junction transistor relaxation oscillator circuit diagram.

- The **capacitor C** charges according to the voltage

$$V = V_o \, (1 - e^{-t / R_1 C})$$

- The **capacitor C** usually starts charging through Resistor **R1** and continues to charge until the maximum voltage **$V_{BB}$**. But in this circuit, when the voltage across **capacitor C** reaches a value, which enables the **UJT** to **turn ON** (the **peak voltage $V_P$**) then the **capacitor C** stops to charge and starts discharging through **Resistor R2** and **switching device** it self **UJT** present in the circuit.

- Now, this discharging continues until the minimum voltage which turns the **UJT OFF** (the **valley voltage $V_V$)**. This process **continues** and the **voltage across** the **capacitor C and Resistor R2** the following waveform is observed and **indicated on a graph** which is shown in **Fig (10)** in next slide.




- **Fig. (10)** Shown relaxation oscillator (sawtooth) output voltage waveforms across capacitor and resistor.

- If the capacitor is charged to the voltage $V_P$ in time T, we can write,

$$V_P = V_{BB} ( 1 - e^{-t / R_1 C} )$$

$$\eta = 1 - e^{-t / R_1 C}$$

$$T = R_1 C \ln [ ( 1 / 1 - \eta ) ]$$

**Above equation gives the time period of the relaxation oscillator.**

- For calculating the oscillating frequency we can use the following formula,

$$f = 1 / T$$

$$f = 1 / R_1 C \ln [ ( 1 / 1 - \eta ) ]$$

- **The standard value of the stand-off ratio for a typical UJT device is between 0.4 and 0.6**. Thus considering the value of $\eta = 0.5$, and substituting it in the above equation we get:

$$f = 1 / R_1C \ln [ ( 1 / 1 – 0.5 )]$$

$$f = 1.44 / R_1C \ln 2$$

$$f = 1.44 / R_1C$$

$$f = 1.5 / R_1C$$

- So, the **charge** and **discharge** of capacitor produces the sweep waveform as shown in **Fig (10)** in previous slide. The **charging** time of **Capacitor C** produces **increasing sweep** and the **discharging** time of **Capacitor C** produces **decreasing sweep**. The **repetition** of this cycle forms a continuous sweep output waveform. As the output is a non-sinusoidal waveform and due to this relaxing state of the oscillator hence this circuit is said to be working as a relaxation oscillator.

**to be continued ...............**