Uni-Junction Transistor (UJT)

Lecture – 2

TDC PART – I

Paper – I (Group – B)

Chapter - 8

by:

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UJT Parameters

(1) Inter Base Resistance (R_{BB})

- It is the resistance between **(Base2)** B_2 and **(Base1)** B_1 *i.e.* it is the **total resistance of the silicon bar from one end to the other** with **emitter terminal open** i.e. When $I_E = 0$. **Inter Base Resistance R_{BB}** shown in **Fig. (3) (*a*).** In simple words, it is the resistance of the **N-Type** bar when measured lengthwise. If R_{B1} is the resistance of the bar from **E** to **B1** and R_{B2} is the resistance of the bar from **E** to **B2**.

- From the equivalent circuit of UJT shown in **Fig (3) (*b*),** it is seen that R_{BB} can be expressed as,

$$R_{BB} = R_{B2} + R_{B1}$$

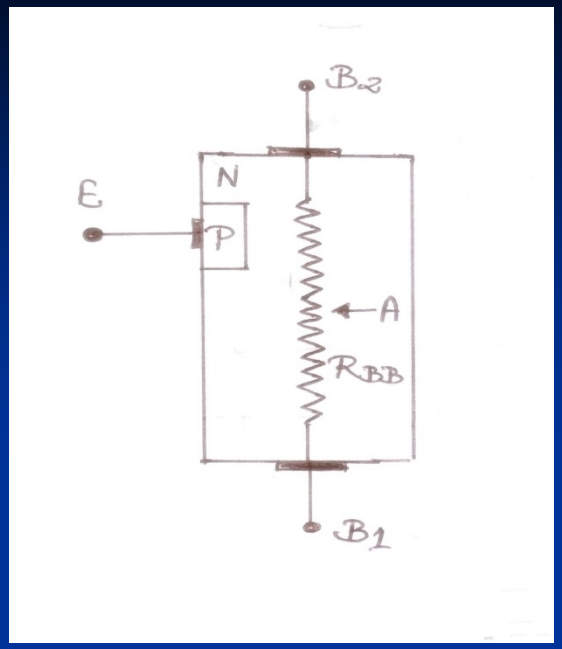


Fig. (3) (a)

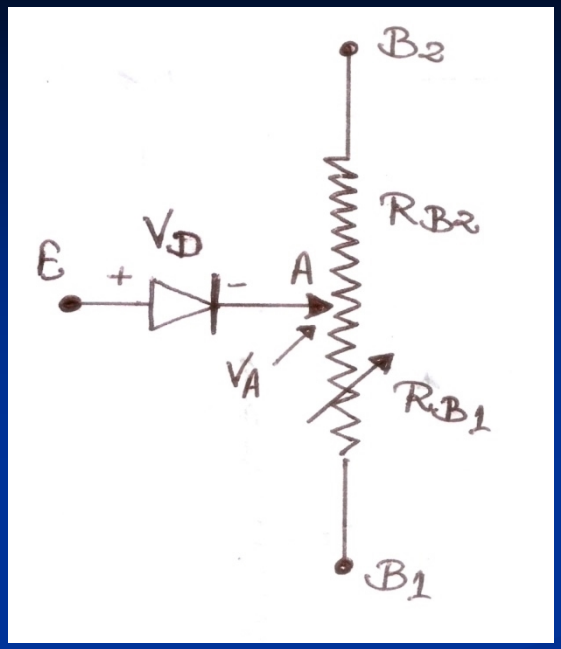


Fig. (3) (b)

Fig. (3) (a) Shown UJT internal view with Inter-Base Resistance RBB.
Fig. (3) (b) Shown UJT Equivalent Internal Circuit With voltage Divider.

- It should also be noted that point ***A*** is such that $R_{B1} > R_{B2}$. Usually, R_{B1} **= 60%** of R_{BB}. The typical range of **Inter Base Resistance RBB** is from **4KΩ** to **10KΩ**. The resistance R_{B1} has been shown in **Fig. (3) (b)** as a variable resistor because its value varies inversely as **Emitter Current IE.**

(2) Intrinsic Stand-off Ratio (η)

- As seen from **Fig. (4) (*a*)**, when a battery of **30 V** is applied across **(Base2)** B_2 and **(BASE1)** B_1, there is a progressive fall of voltage over R_{BB} provided **(Emitter)** ***E*** is open. It is obvious from **Fig. (4) (*b*)** that Emitter acts as a voltage-divider tap on fixed resistance R_{BB}. With emitter open, $I_1 = I_2$, the **Inter-base Current** is given by Ohm's Law.

$$I_1 = I_2 = V_{BB} / R_{BB}$$

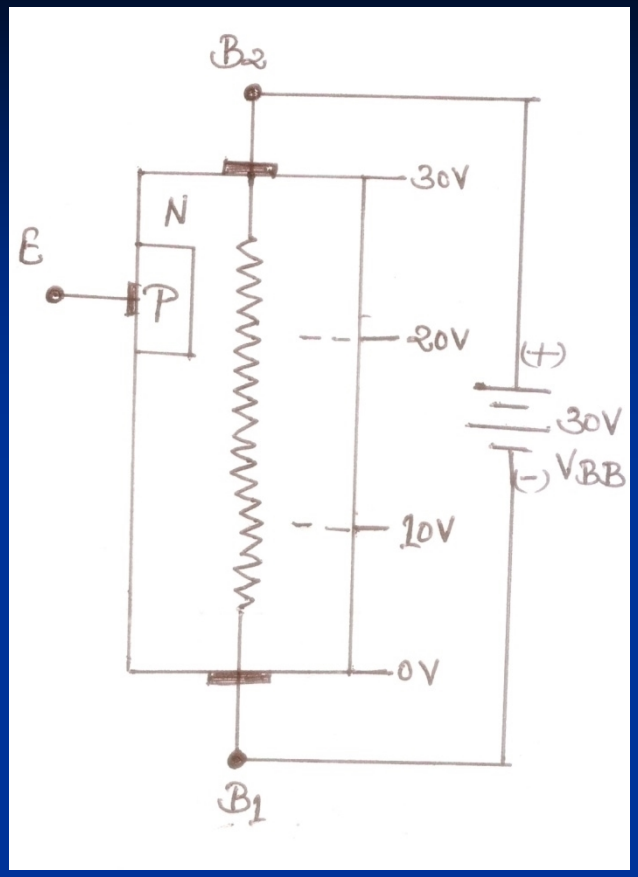


Fig. (4) (a)

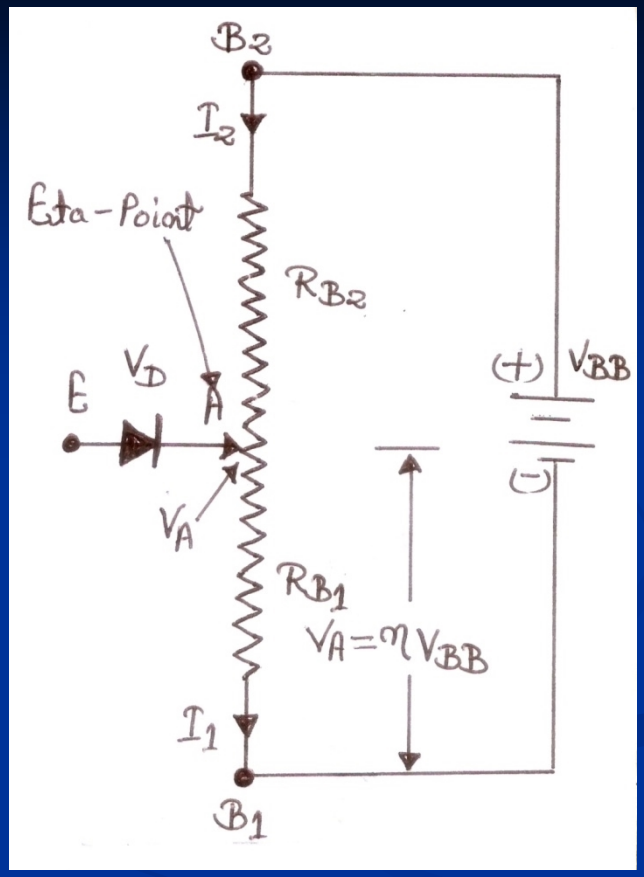


Fig. (4) (B)

Fig. (4) (a) Shown UJT when a battery of 30 V is applied across *B*2 *B*1.

Fig. (4) (b) Shown UJT Equivalent Circuit , Emitter acts as a voltage-divider tap on fixed resistance RBB with **Eta – Point**.

For example: -

- **<u>For example</u>: -** if V_{BB} = 30 V and R_{BB} = 15 K, $I1 = I2 = 2$ mA.

- It may be noted that part of V_{BB} is dropped over R_{B2} and part on R_{B1}. Let us call the voltage drop across R_{B1} as V_A. Using simple **voltage divider** relationship,

$$V_A = V_{BB} \ (R_{B1} / R_{B1} + R_{B2})$$

- The **voltage division factor** is given a special symbol (η) and the name of '**intrinsic stand – off ratio**'. **Intrinsic stand – off ratio** is the ratio of R_{B1} to the sum of R_{B1} and R_{B2}. It can be expressed as,

$$\eta = R_{B1} / R_{B1} + R_{B2}$$

$$V_A = \eta \; V_{BB}$$

- The **Intrinsic Stand-off Ratio (η)** is the property of the **UJT** and is always **less than unity (0.4 to 0.85).** If V_{BB} = 30 V and η = 0.6, then potential of point **A** with respect to point **B1** = 0.6 × 30 = 18 V. The remaining 12 V drop across R_{B2}.

(2) Intrinsic Stand off Ratio (η) by 2nd Method

- **Fig. (5),** show a battery **V_{BB}** connected across Base **B_2** and **B_1** of equivalent circuit of **UJT.** Here **emitter** point **E** acts as a **Voltage Divider Tap**on the **fixed resistance R_{BB}**. It is obvious that part of **V_{BB}** is dropped over **R_{B2}** and part on **R_{B1}**. Let the voltage drop across **R_{B1}** is **V_{RB1}**, then the magnitude of **V_{RB1} (**with **$I_E = 0$)** is equal to **V_A**. According to the simple voltage divider rule we get,

$$V_{RB1} = V_A = V_{BB} (R_{B1} / R_{B1} + R_{B2}) \text{ ---- } I_E = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, $R_{BB} = R_{B1} + R_{B2}$

- **R_{BB} Inter Base Resistance** when no voltage is applied to the emitter).

- From equation (1), we have,

  $V_A / V_{BB} = R_{B1} / R_{B1} + R_{B2}$ ..... (2)

- The ratio V_A / V_{BB} is called the intrinsic- stand off ratio and is represented by η .

  Hence ,

  $\eta = R_{B1} / R_{B1} + R_{B2} = R_{B1} / R_{BB}$ ---- $I_E = 0$ ..... (3)

- The **Intrinsic Stand-off Ratio (η)** is the property of the **UJT** and is always **less than unity(0.4 to 0.85). Voltage** across R_{B1} is,

  $V_{RB1} = V_A = (R_{B1} / R_{BB}) V_{BB}$ ---- $I_E = 0$ ..... (4)

  $V_{RB1} = V_A = \eta V_{BB}$ ---- $I_E = 0$ ..... (5)

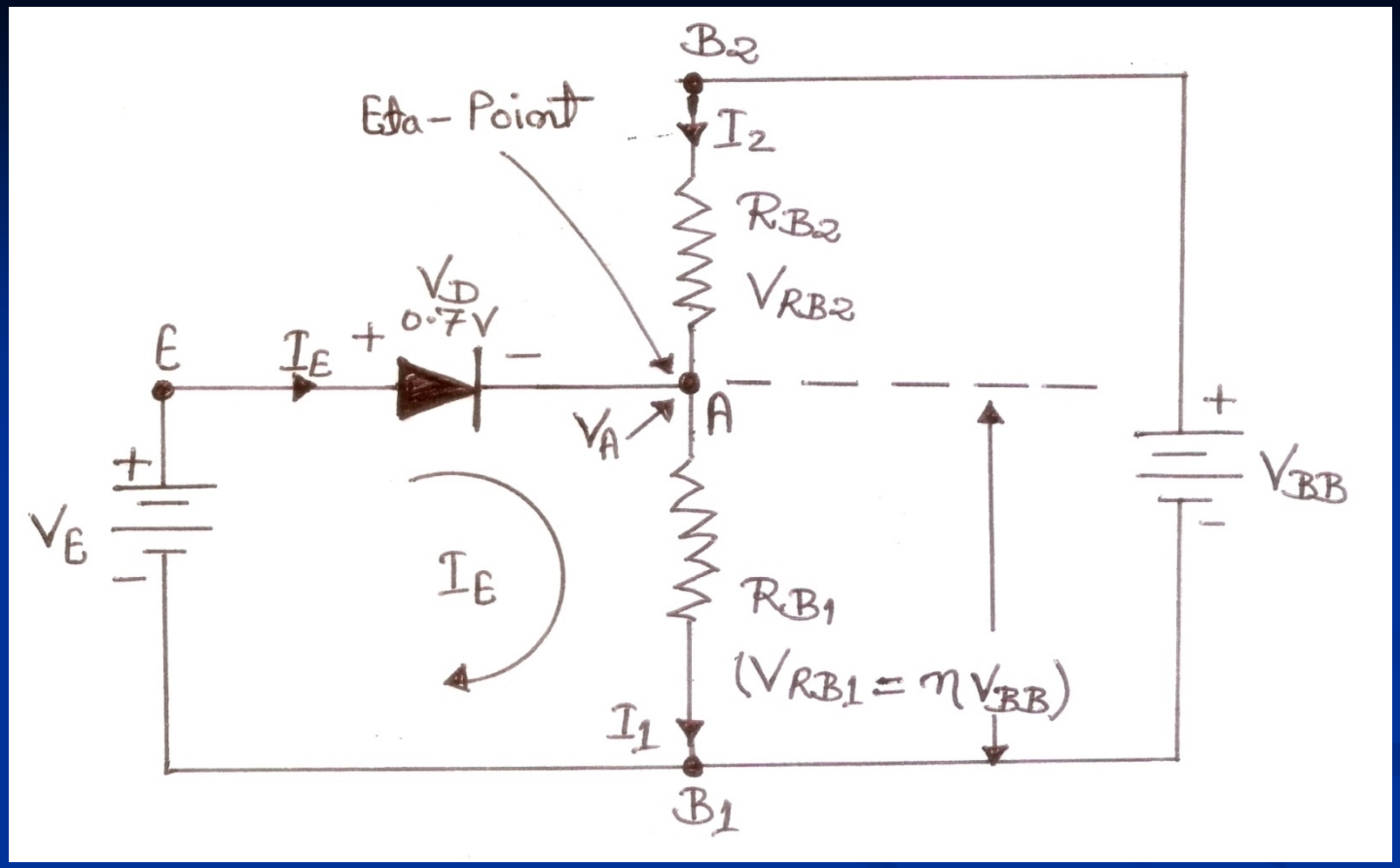


Fig. (5) Shown Typical UJT Equivalent Circuit Diagram.

- The voltage **η VBB** appearing across **RB1** Reverse-Biases the diode and hence the Emitter Current **IE = 0**

(2) Intrinsic Stand off Ratio (η) by 3rd Method

- **Intrinsic Stand off Ratio (η)** can be describe as,

  when Inter Base Voltage **(V_{BB})** is applied across the two base terminals B1 and B2 shown in Fig. (5) the potential of point A with respect to B1 is given by

$$V_{AB1} = (V_{BB} / R_{B1} + R_{B2}) R_{B1}$$

$$V_{AB1} = (R_{B1} / R_{B1} + R_{B2}) V_{BB}$$

$$V_{AB1} = \eta V_{BB}$$

Where, $\eta = R_{B1} / R_{B1} + R_{B2}$

- **η** (nita) is called the **Intrinsic Stand off Ratio (η)**.

- The **Intrinsic Stand off Ratio** is the property of the **UJT** and is always **less then Unity**. The typical value of **η** are .51 to .82.

(3) Circuit Arrangement For UJT V-I Characteristics

- For ease of understanding, the internal model of the **UJT** is used in the circuit shown in **Fig (6). (Base2) B2** terminal of the **UJT** is **made positive** with respect to **(Base1) B1** terminal using the **voltage source V_{BB}. Emitter** terminal **E** of the **UJT** is **forward biased** using the **voltage source V_E. Current starts flowing** into the **emitter only** when the **bias voltage V_E** has **exceeded the forward voltage drop of the internal diode (V_D) (0.7V)** plus the **voltage drop across R_{B1} (V_{RB1}).** This condition can be expressed using the following equation below,

$$V_E = V_D + V_{RB1}$$

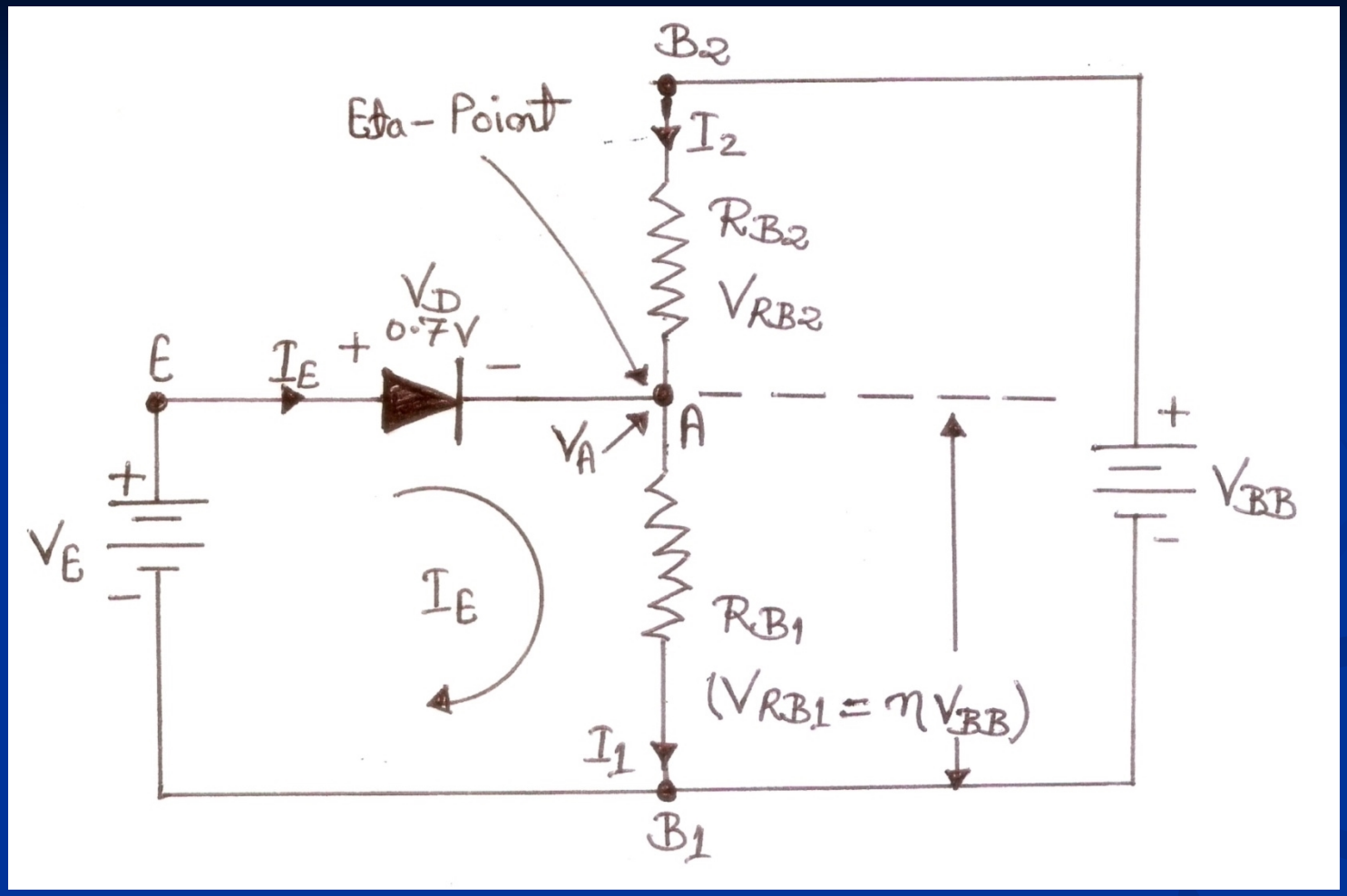


Fig. (6) Shown Typical UJT Equivalent Circuit Diagram for V – I Characteristics

- Considering the intrinsic stand off ratio

  $$\eta = R_{B1} / (R_{B1}+R_{B2}),$$

  then the equation becomes

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

- A **typical silicon diode** has a **forward voltage drop of** $V_D = 0.7V$. When this factor is considered, the equation can be re written as,

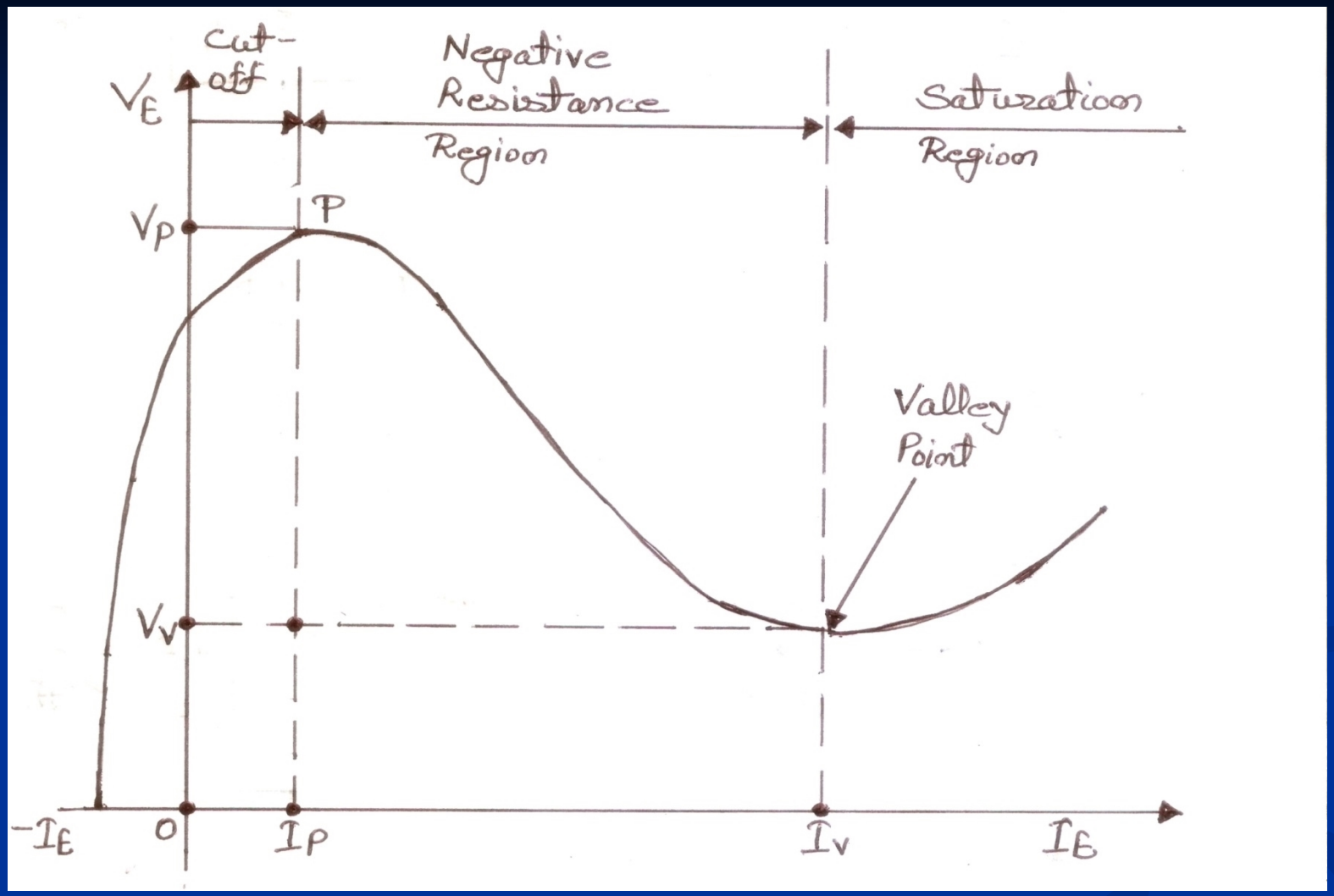
  $$V_E = 0.7V + \eta V_{BB}$$

- **This minimum value** of the **Emitter Voltage** V_E for which the **Emitter Current** I_E starts to flow is called the **Firing Voltage of UJT**.

- As the **Emitter Voltage V_E** is **increased** the **emitter current I_E** is also **increased** and the **junction behaves** like a **typical P-N junction**. But the **Emitter Voltage V_E** can be only **increased up** to a **particular point** called **V_P (peak voltage).**

- At this point a considerable amount of **Emitter Current I_E flows** and a significant number of **holes** are **injected into the junction**. These **holes** are **repelled** by **(Base2) B_2** and attracted by **(Base1) B_1**. As a result, the **region between Emitter (E)** and **(Base1) B_1 terminal starts Saturating by holes** and the **conductivity** of this region starts to **increase.** This phenomenon of increasing conductivity by the insertion of holes is called **Conductivity Modulation**.

- This **increased conductivity reduces R_{B1}** and **Intrinsic Stand of Ratio (η).** This results in a condition where **emitter current I_E increases** and the **emitter voltage V_E decrease. This situation is similar to a Negative Resistance scenario.** In the **V - I Characteristic of UJT** which shown is in Fig. (7) in next slide, we can see that the regions between **V_P (peak voltage point)** and **Vv (valley voltage)** have a negative slope. This **negative resistance region** in the **UJT characteristics** is employed in **Oscillator Circuit.**



- **Fig. (7)** Shown V-I Characteristics of UJT with Negative Resistance.

- At last the emitter current **I_E** will be increased to a point that no more increase in conductivity is possible. This point is called **"Valley point".** The emitter current corresponding to valley point is denoted as **I_v** and the corresponding **Emitter Voltage** is denoted as **V_v**. Beyond the valley point, the **UJT** is **Fully Saturated** and the junction behaves like a **Fully saturated P-N junction**.

to be continued.....