SCR & UJT

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Introduction

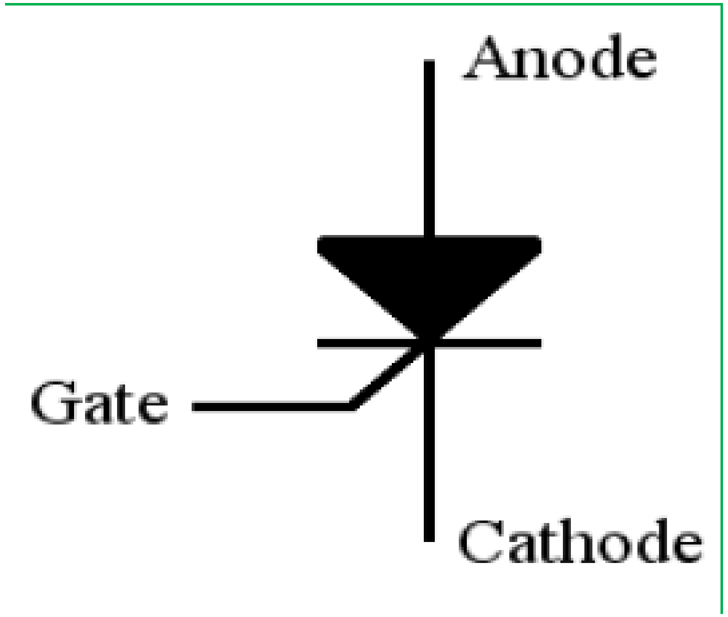
The silicon-controlled rectifier(SCR) which is a power electronic device is unquestionable of the greatest interest today. It was first introduced in 1956 by Bell Telephone Laboratories. It can convert alternating current into direct current and at the same time can control the amount of power fed to the load. Thus it combines the features of a rectifier and a transistor.

What is a silicon control rectifier?

- A Silicon Controlled Rectifier (SCR) is a four layer solid state device that controls current flow. SCR is a three terminal device.

The terminals are:

- Gate (G)
- Anode (A)
- Cathode (K)



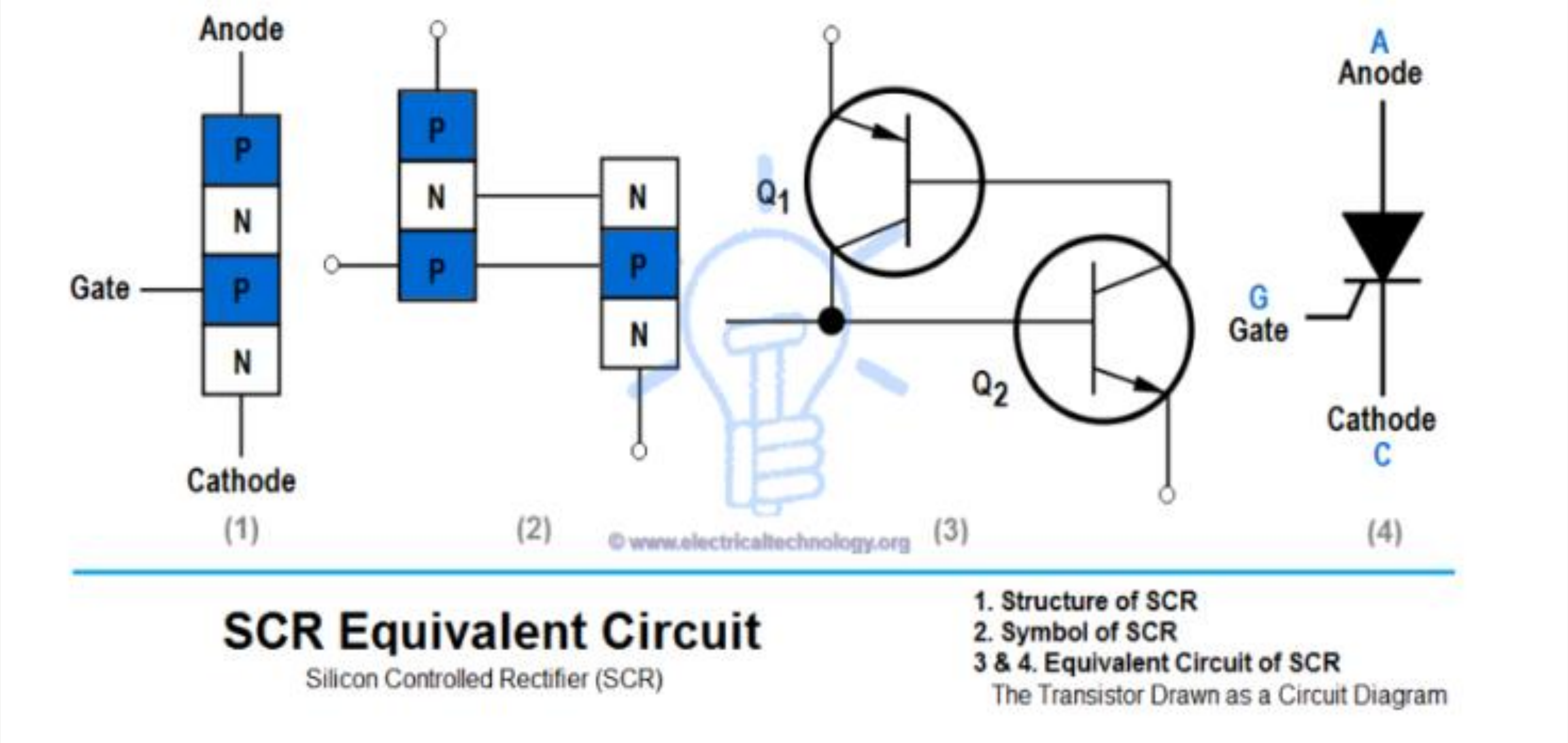
- Two main uses of SCR are:

- Switching
- Amplification

Basic SCR structure

- The SCR consists of a four layer p-n-p-n structure with the outer layers are referred to as the anode (p-type) and cathode (n-type). The control terminal of the SCR is named the gate and it is connected to the p-type layer located next to the cathode.
- The three junctions are normally denoted as J_1, J_2, and J_3. They are numbered serially with J_1 being nearest to the anode.

Silicon Controlled Rectifier (SCR)



How does SCR work?

- Load is connected in series with anode.
- The anode is always kept at a higher potential than the cathode.

The working of SCR is to be studied under two different conditions:

1. When Gate (G) is open
2. When Gate (G) is positive with respect to Cathode (K)

-When Gate is Open

no voltage to the gate. J_2 is reverse biased while J_1 & J_3 are forward biased. reverse bias, no current will flow through the device => SCR is cut-off.

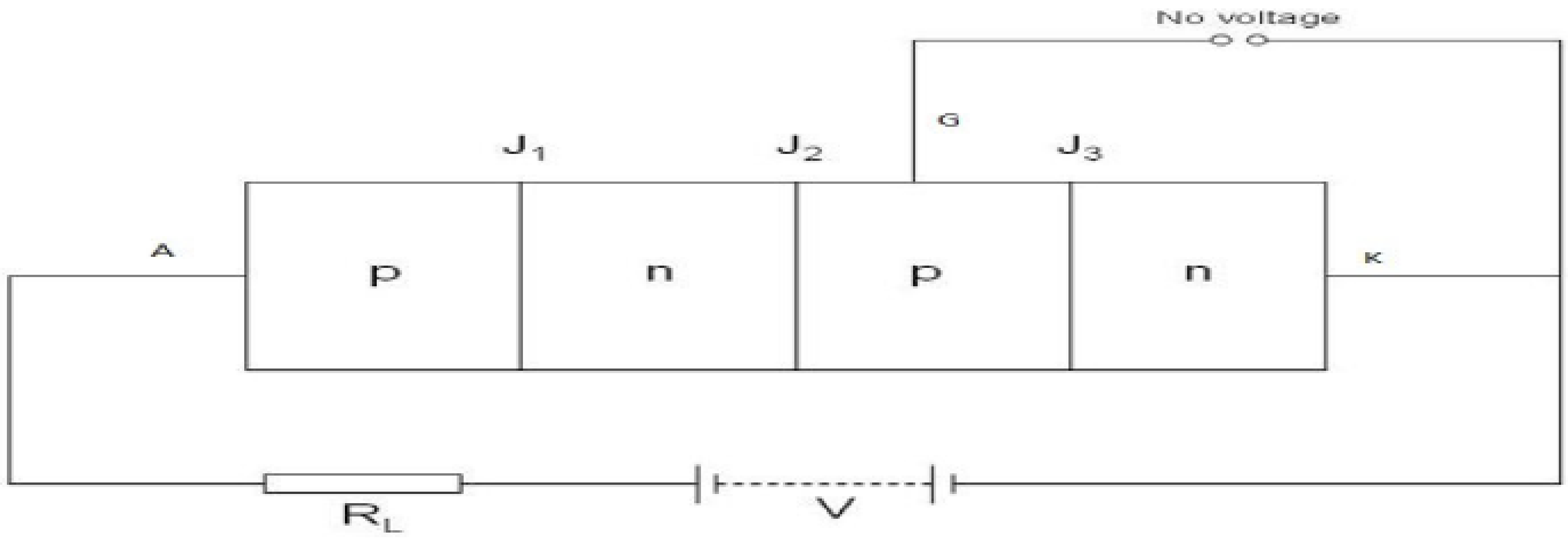


Fig: SCR with gate open

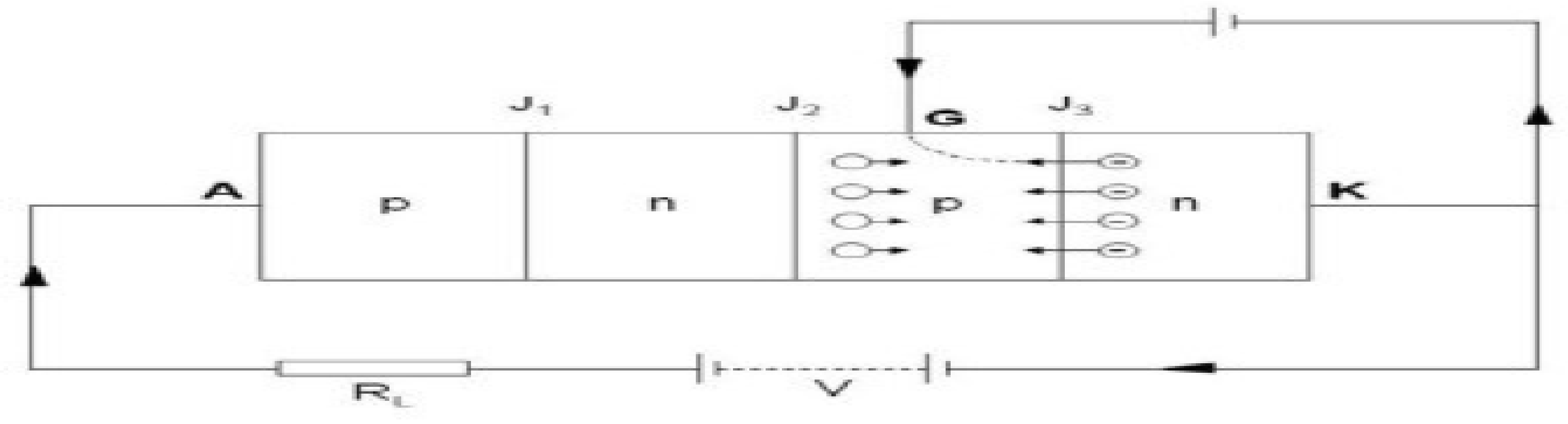
When Gate is positive with respect to cathode

•J3 is forward biased, J2 is reverse biased.

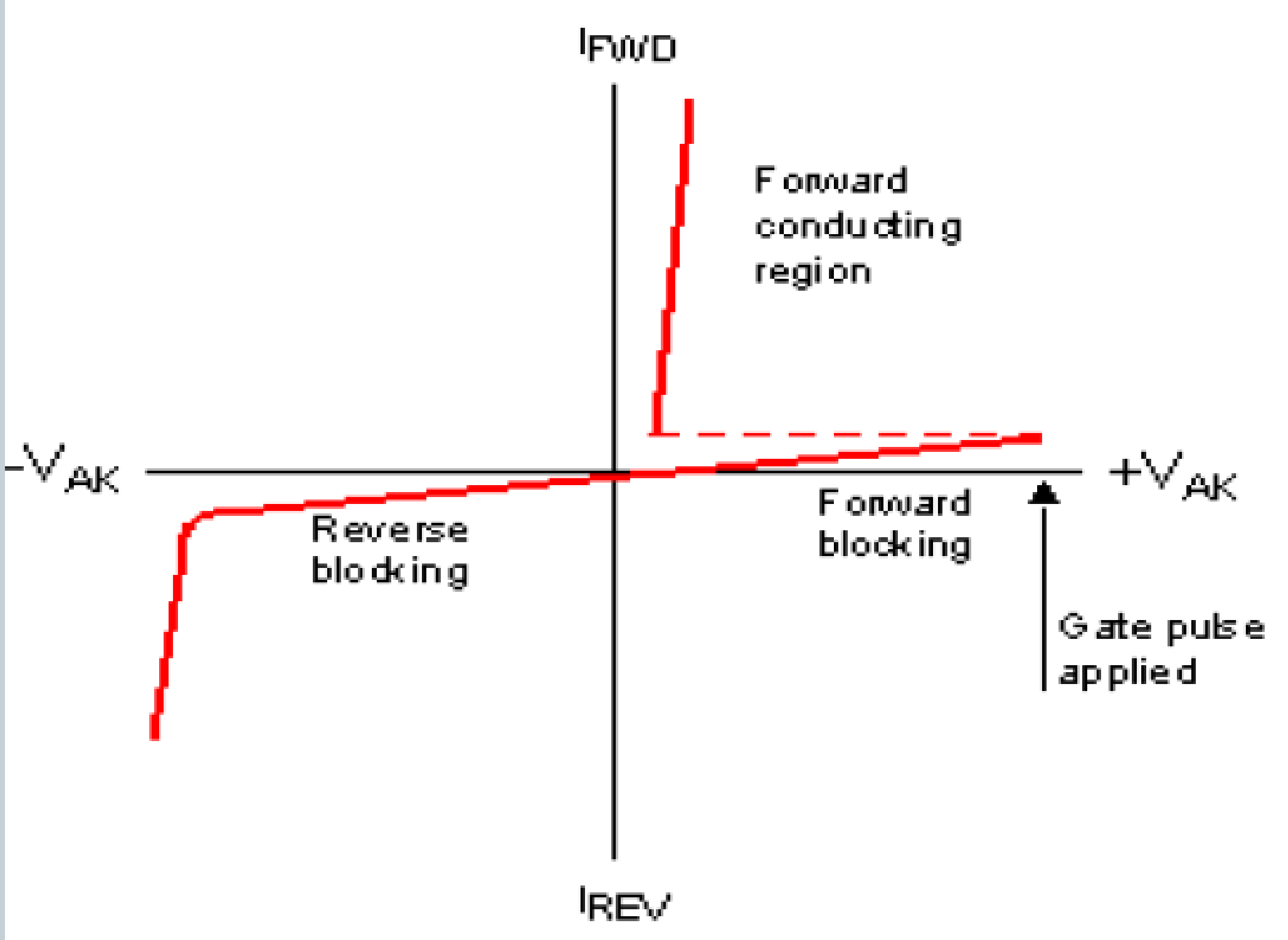
•Electrons from n-type material start moving across J3 towards left

•Similarly, holes move from p-type material towards the right.

•Eventually, the electrons that moved across J3 are now attracted across J2. This initiates the Gate current and the J2 is now conducting .



Characteristics curve



The SCR has three basic states:

1. Forward blocking mode or off state: In this mode or state the SCR operation is such that it blocks forward current conduction that would normally be carried by a forward biased diode.

2. Forward conduction mode or on state: In this mode the SCR has reached into conduction.

3. Reverse blocking mode or off state: In this mode or state the SCR blocks the current in the same way as that of a reverse biased diode.

Application for SCRs:

1. Rectification ,
2. Regulated power suppliers,
3. Static switches ,
4. Motor speed controls and,
5. Battery charger and heater controls, etc.

Unijunction transistor

❖The UJT as the name implies, is characterized by a single pn junction.
❖It exhibits negative resistance characteristic that makes it useful in oscillator circuits.

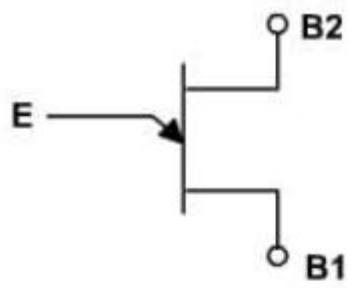


Fig. 1 Symbol

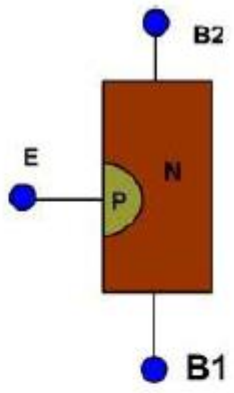


Fig.2 Layered diagram

- The symbol for UJT is shown in **fig. 1**. The UJT is having three terminals base1 (B1), base2 (B2) and emitter (E).

- The UJT is made up of an N-type silicon bar which acts as the base as shown in **fig. 2**. It is very lightly doped.

- A P-type impurity is introduced into the base, producing a single PN junction called emitter. The PN junction exhibits the properties of a conventional diode.

- A complementary UJT is formed by a P-type base and N-type emitter. Except for the polarity of voltage and current the characteristic is similar to those of a conventional UJT.

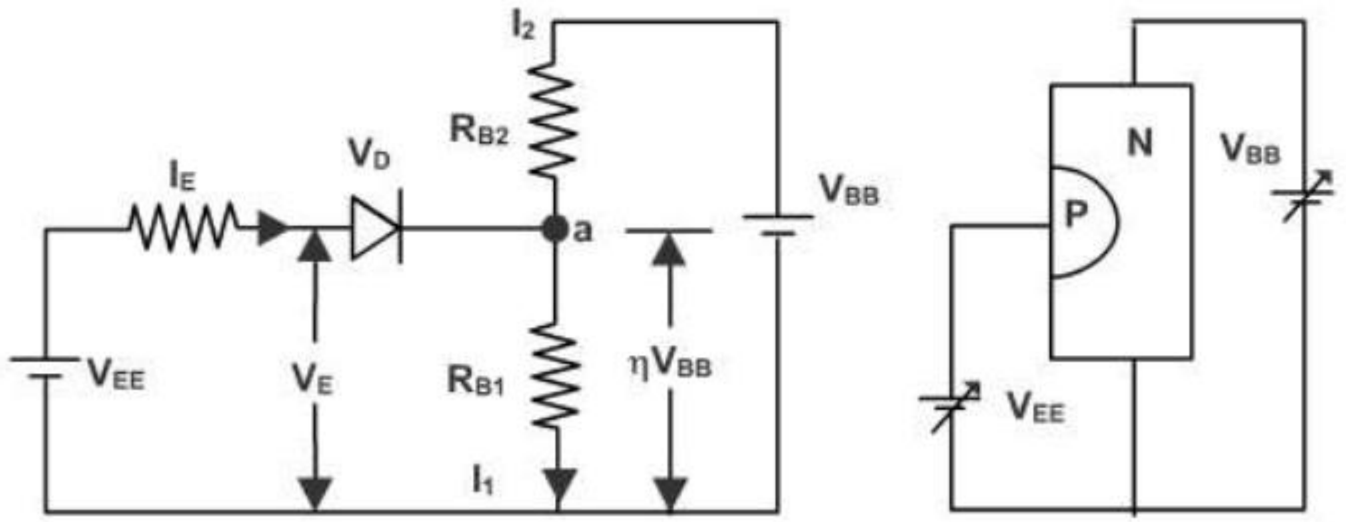


Fig.3 UJT equivalent circuit

- A simplified equivalent circuit for the UJT is shown in fig. 3.

- V_{BB} is a source of biasing voltage connected between B2 and B1

- When the emitter is open, the total resistance from B2 to B1 is simply the resistance of the silicon bar, this is known as the inter base resistance R_{BB}. Since the N-channel is lightly doped, therefore R_{BB} is relatively high, typically 5 to 10K ohm.
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- R_{B2} is the resistance between B2 and point 'a', while R_{B1} is the resistance from point 'a' to B1, therefore the interbase resistance R_{BB} is

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

Working

❖The diode accounts for the rectifying properties of the PN junction. V_D is the diode's threshold voltage. With the emitter open, $I_E = 0$, and $I_1 = I_2$. The interbase current is given by

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

❖ Part of V_{BB} is dropped across R_{B2} while the rest of voltage is dropped across R_{B1}. The voltage across R_{B1} is

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

❖The ratio $R_{B1} / (R_{B1} + R_{B2})$ is called intrinsic standoff ratio

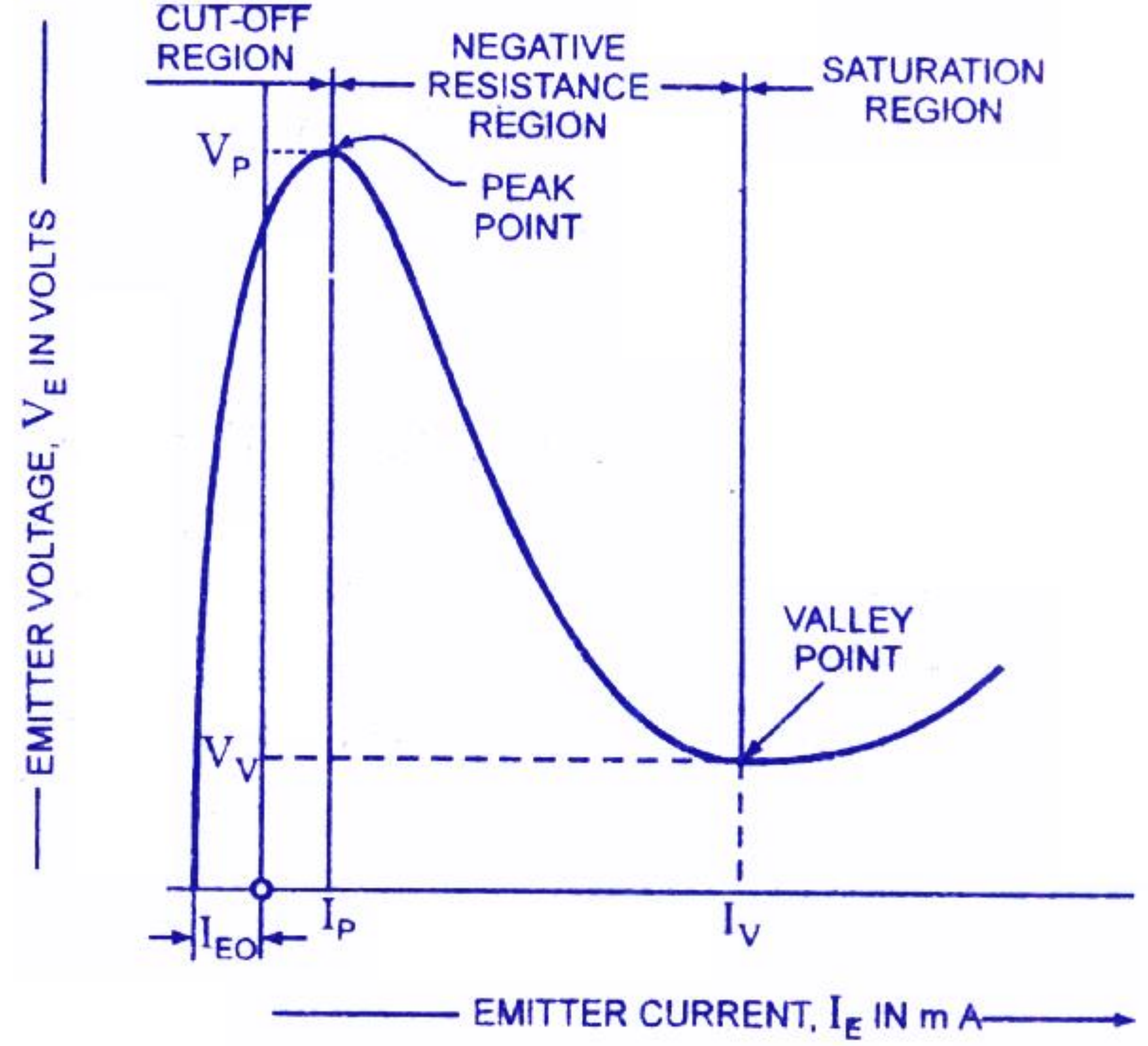
$$\eta = R_{B1} / (R_{B1} + R_{B2}) \text{ i.e. } V_a = \eta V_{BB} .$$

❖The ratio η is a property of UJT and it is always less than one and usually between 0.4 and 0.85.

- As long as $I_B = 0$, the circuit of behaves as a voltage divider. Assume now that v_E is gradually increased from zero using an emitter supply V_{EE} . The diode remains reverse biased till v_E voltage is less than ηV_{BB} and no emitter current flows except leakage current. The emitter diode will be reversed biased.

- When $v_E = V_D + \eta V_{BB}$, then appreciable emitter current begins to flow where V_D is the diode's threshold voltage. The value of v_E that causes, the diode to start conducting is called the peak point voltage and the current is called peak point current I_P.

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



Static Emitter-Characteristic For a UJT

- The region from $v_E = 0$ to $v_E = V_P$ is called cut off region because no emitter current flows (except for leakage).

- Once v_E exceeds the peak point voltage, I_E increases, but v_E decreases. up to certain point called valley point (V_V and I_V). This is called negative resistance region. Beyond this, I_E increases with v_E this is the saturation region, which exhibits a positive resistance characteristic.

- The physical process responsible for the negative resistance characteristic is called conductivity modulation. When the v_E exceeds V_P voltage, holes from P emitter are injected into N base. Since the P region is heavily doped compared with the N-region, holes are injected to the lower half of the UJT.

- The lightly doped N region gives these holes a long lifetime. These holes move towards B1 to complete their path by re-entering at the negative terminal of V_{EE}. The large holes create a conducting path between the emitter and the lower base. These increased charge carriers represent a decrease in resistance R_{B1}, therefore can be considered as variable resistance. It decreases up to 50 ohm.

Queries

Thank You