Silicon Controlled Rectifier (SCR)

PRESENTED BY

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Introduction

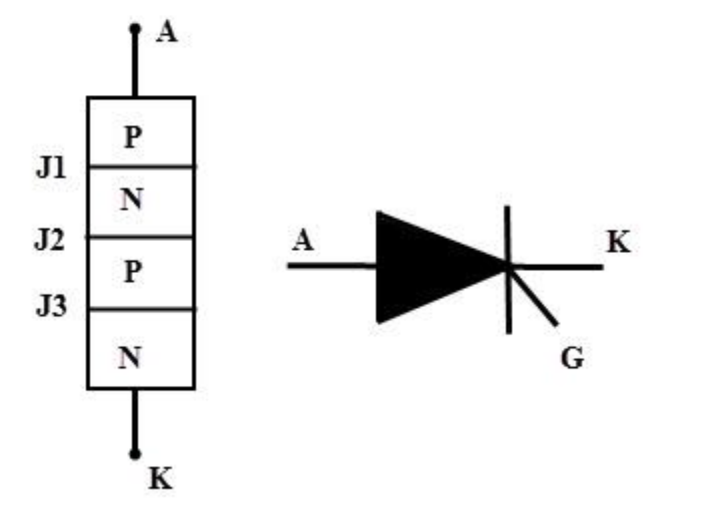
- The Silicon Controlled Rectifier (SCR) is the most important and mostly used member of the thyristor family.
- SCR is a unidirectional device that allows the current in one direction.
- SCR is a controlled turn on and un controlled turn off device.
- SCR is a three terminal; anode, cathode and gate and four

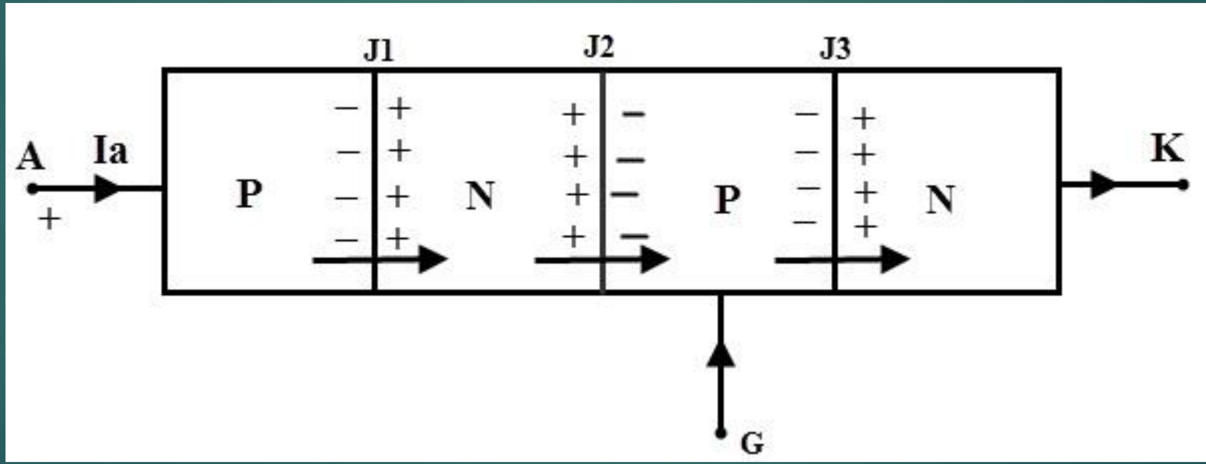
Layer (PNPN) device.

- Outer P layer is Anode (A), outer N layer is Cathode (K) and

The inner P layer is Gate (G).

- The outer layers (P and N-layers) are heavily doped where as middle P and N-layers are lightly doped.
- To manufacture the SCR, three types of constructions are used, namely the planar type, alloy type and Press diffusion type.
- This construction is mainly used for high power Silicon Controlled Rectifiers.


A
P
J1
N
J2
P
J3
N
K
A
K
G


J1
J2
J3
A
Ia
+
P
N
P
N
K
G

Modes of Operation of SCR

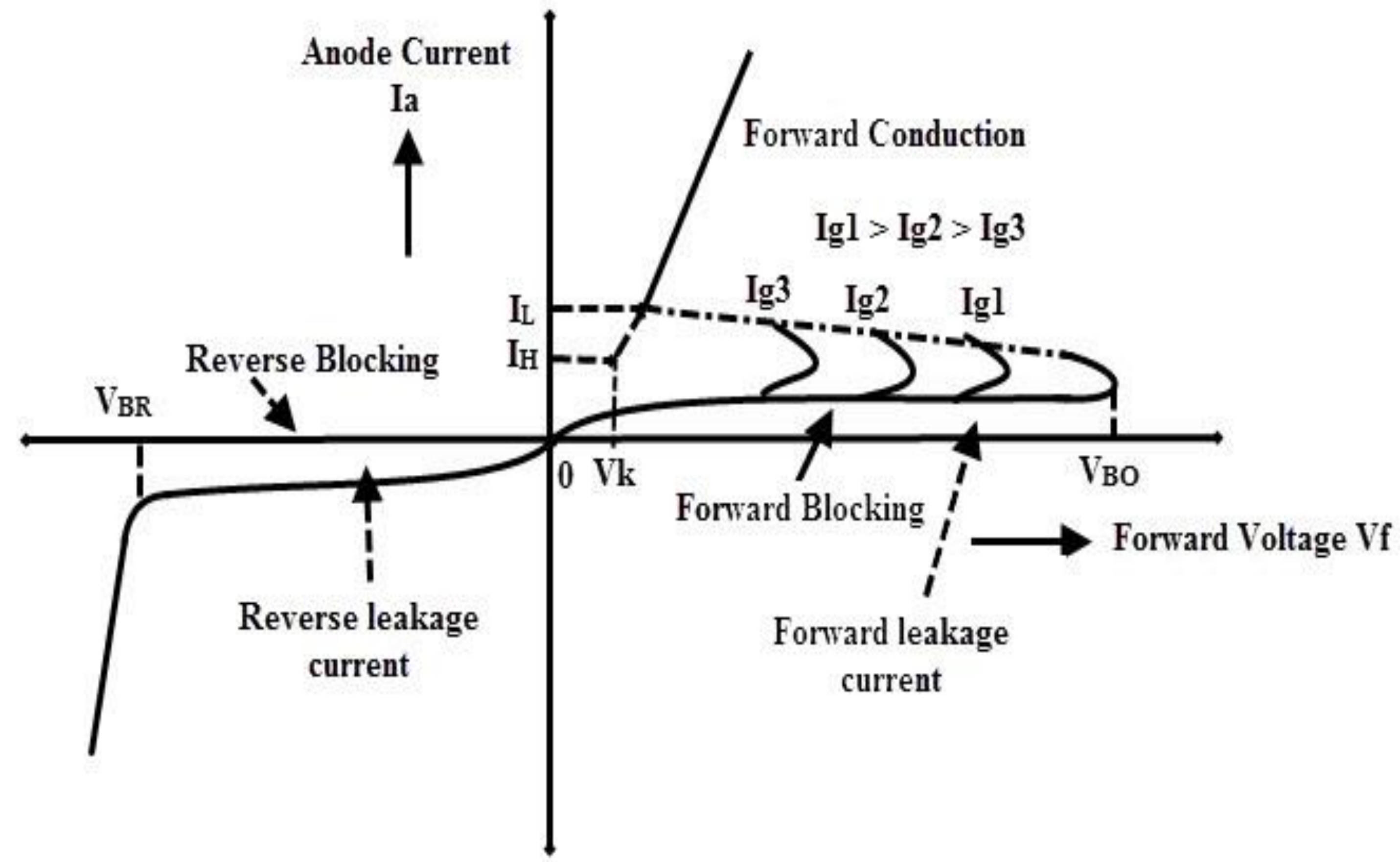
- Depending on the biasing given to the SCR, the operation of SCR is divided into three modes. They are
  - Forward blocking Mode
  - Forward Conduction Mode
  - Reverse Blocking Mode

Forward blocking Mode

- The anode terminal is made positive with respect to cathode while the gate terminal kept open.
- In this state junctions J1 and J3 are forward biased and the junction J2 reverse biased.
- Due to this, a small leakage current flows through the SCR. Until the voltage applied across the SCR is more than the break over voltage of it, SCR offers a very high resistance to the current flow.
- Therefore, the SCR acts as a open switch in this mode by blocking forward current flowing through the SCR

Forward Conduction Mode

- In this mode, SCR or thyristor comes into the conduction mode from blocking mode.
- It can be done in two ways as either by applying positive pulse to gate terminal or by increasing the forward voltage (or voltage across the anode and cathode) beyond the break over voltage of the SCR.
- Once any one of these methods is applied, the avalanche breakdown occurs at junction J2. Therefore the SCR turns into conduction mode and acts as a closed switch thereby current starts flowing through it.
- if gate current is increasing, the voltage required to turn ON the SCR is less.
- The current at which the SCR turns into conduction mode from blocking mode is called as latching current (IL).
- When the forward current reaches to level at which the SCR returns to blocking state is called as holding current (IH). At this holding current level, depletion region starts to develop around junction J2. Hence the holding current is slightly less than the latching current.



Anode Current
Ia
Forward Conduction
Ig1 > Ig2 > Ig3
IL
IH
Ig3
Ig2
Ig1
Reverse Blocking
VBR
0
Vk
VBO
Forward Blocking
Forward Voltage Vf
Reverse leakage current
Forward leakage current

Reverse Blocking Mode

- In this mode of operation, cathode is made positive with respect to anode.
- The junctions J1 and J3 are reverse biased and J2 is forward biased. This reverse voltage drives the SCR into reverse blocking region results to flow a small leakage current through it and acts as an open switch.
- The device offers a high impedance in this mode until the voltage applied is less than the reverse breakdown voltage VBR of the SCR.
- If the reverse applied voltage is increased beyond the VBR, then avalanche breakdown occurs at junctions J1 and J3 which results to increase reverse current flow through the SCR.
- This reverse current causes more losses in the SCR and even to increase the heat of it.
- So there will be a considerable damage to the SCR when the reverse voltage applied more than VBR.

Application

- AC power control (including lights, motors,etc).
- Overvoltage protection crowbar for power supplies.
- AC power switching.
- Control elements in phase angle triggered controllers.
- Photographic flash lights

Uni Junction Transistor (UJT)

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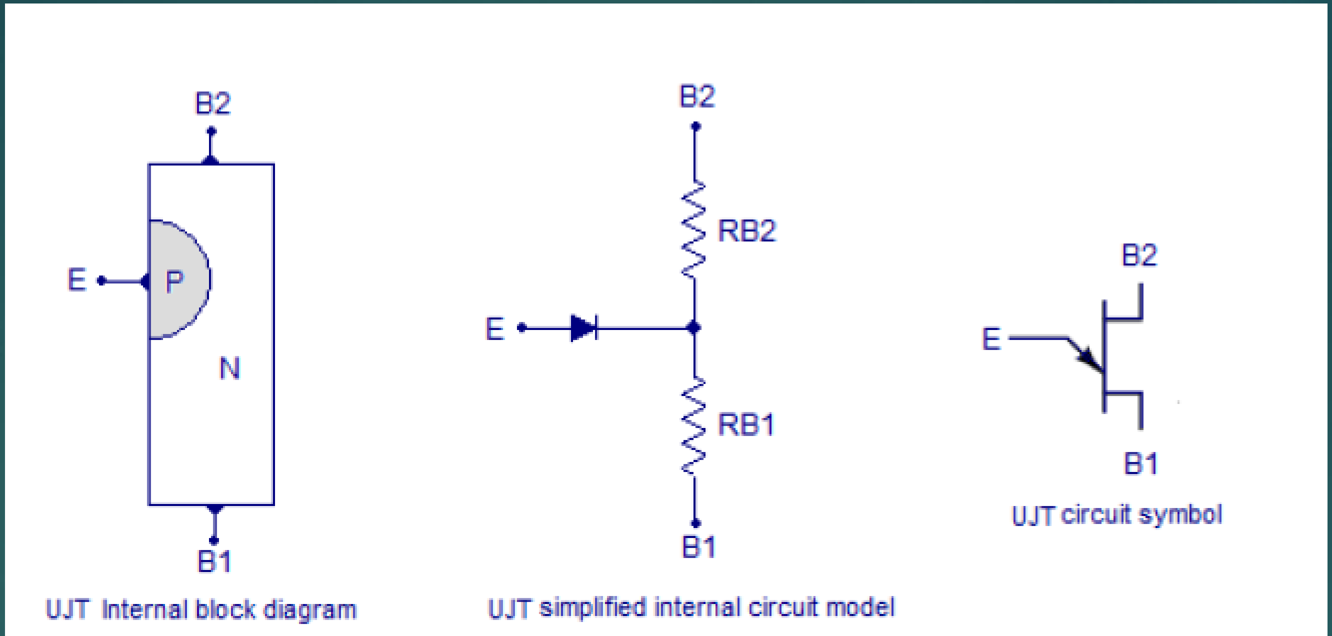
Introduction

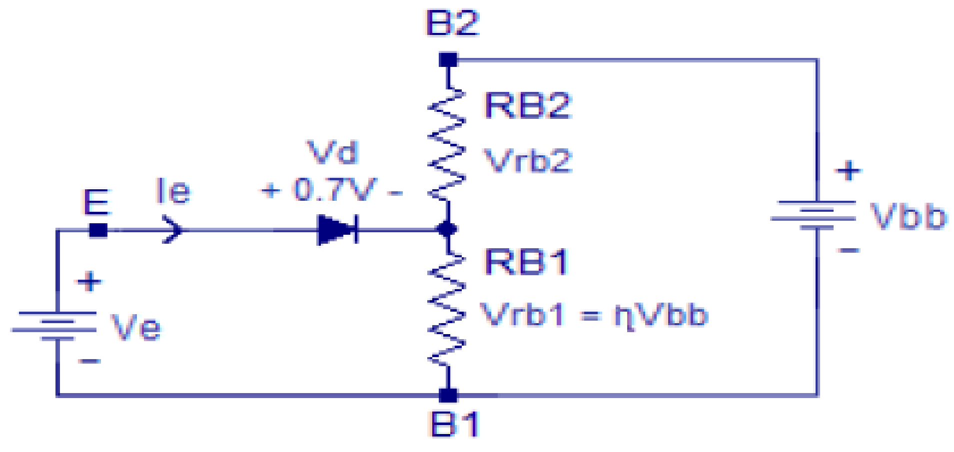
- A unijunction transistor (abbreviated as UJT) is a three-terminal semiconductor switching device.
- Unijunction Transistor is such a transistor that has a single PN junction, but still not a diode. Unijunction Transistor, or simply **UJT** has an emitter and two bases, unlike a normal transistor. This component is especially famous for its negative resistance property and also for its application as a relaxation oscillator.
- only one PN-junction, the device is really a form of diode. Because the two base terminals are taken from one section of the diode, this device is also called double-based diode.
- Since the device has one PN junction and three leads, it is commonly called a unijunction transistor .
- It consists of an n-type silicon bar with an electrical connection on each end. The lead to these connections are called base leads base-one B1 and base two B2.
- Nearer to B2 a PN junction is formed between a p-type emitter and the bar.
- The lead to this junction is called the emitter lead E (Heavily doped)



In the symbol, the emitter is indicated by an inclined arrow and the remaining two ends indicate the bases. As the UJT is understood as a combination of diode and some resistance, the internal structure of UJT can be indicated by an equivalent diagram to explain the working of UJT.

Working of UJT

- The working of UJT can be understood by its equivalent circuit.
- The voltage applied at the emitter is indicated as V_e and the internal resistances are indicated as R_{B1} and R_{B2} at bases 1 and 2 respectively.
- Both resistances present internally are together called as **intrinsic resistance**, indicated as R_{BB}. The voltage across RB1 can be denoted as V_1. The dc voltage applied for the circuit to function is V_{bb} with emitter open.
- The diode d will be in reverse bias.



typical UJT circuit

- A small leakage current flows from B2 to emitter due to minority carriers.
- If a positive voltage is applied at the emitter, the PN junction will remain reverse biased so long as the input voltage is less than V1. If the input voltage to the emitter exceeds V1, the PN junction becomes forward biased.

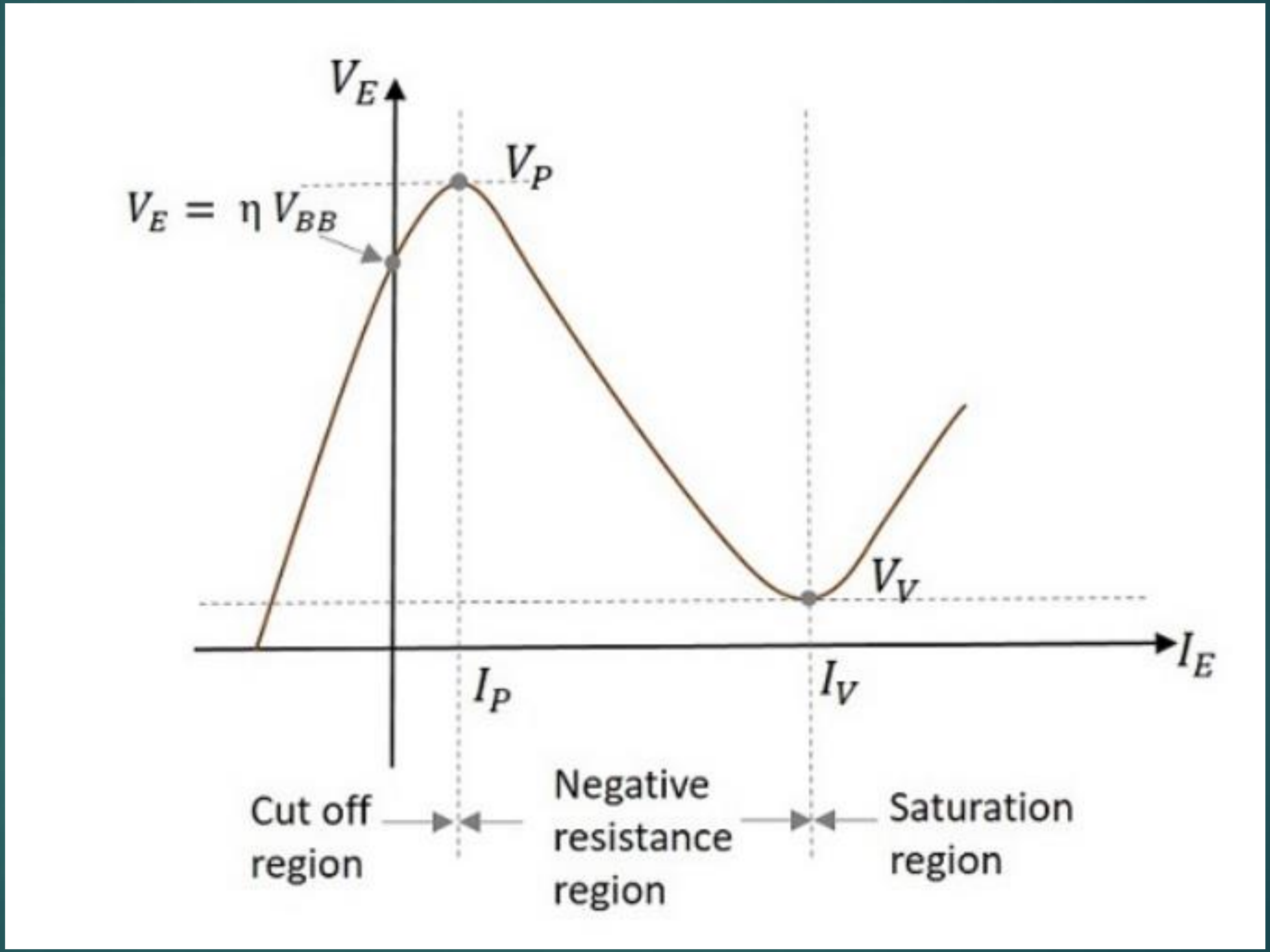
$$V1 = Vbb^* (RB1/(RB1+RB2))$$

$$Ve = Vd + Vrb1 \; ; \; Ve = Vd + \eta \cdot Vbb$$

intrinsic stand off ratio **η = RB1/(RB1+RB2)**

- Under these conditions, holes are injected from p-type material into the n-type bar. These holes are repelled by positive B2 terminal and they are attracted towards B1 terminal of the bar. This accumulation of holes in the emitter to B1 region results in the decrease of resistance in this section of the bar.
- The device is now in the ON state.
- If a negative pulse is applied to the emitter, the PN junction is reverse biased and the emitter current is cut off. The device is then said to be in the OFF state.

Characteristics



- Initially when V_E is zero, some reverse current IE flows until, the value of VE reaches a point at which, VE=ηVBB.
- This is the point where the curve touches the Y-axis. When V_E reaches a voltage where VE=ηVBB+VD.
- At this point, the diode gets forward biased.
- The voltage at this point is called as V_P (**Peak Voltage**) and the current at this point is called as I_P (**Peak Current**). The portion in the graph till now, is termed as **Cut off region** as the UJT was in OFF state.
- Now, when V_E is further increased, the resistance R_{B1} and then the voltage V_1 also decreases, but the current through it increases. This is the **Negative resistance property** and hence this region is called as **Negative resistance region**.
- Now, the voltage V_E reaches a certain point where further increase leads to the increase in voltage across R_{B1}. The voltage at this point is called as V_V (**Valley Voltage**) and the current at this point is called as I_V (**Valley Current**). The region after this is termed as **Saturation region**.

Application

- 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.