5.2 SILICON CONTROLLED RECTIFIER (SCR)

Silicon Controlled Rectifier (SCR) is a unidirectional semiconductor device made of silicon which can be used to provide a selected power to the load by switching it ON for variable amount of time. These devices are solid-state equivalent of thyratrons and are hence referred to as thyristors or thyrode transistors. In fact, SCR is a trade name of General Electric (GE) to the thyristor. Basically SCR is a three terminal, four-layer (hence of three junctions J1, J2 and J3) semiconductor device consisting of alternate layers of p- and n-type material doping. Figure 1a shows the SCR with the layers pnpn which has the terminals Anode (A), Cathode (K) and the Gate (G). Further it is to be noted that the Gate terminal will generally be the p-layer nearer to the Cathode terminal.

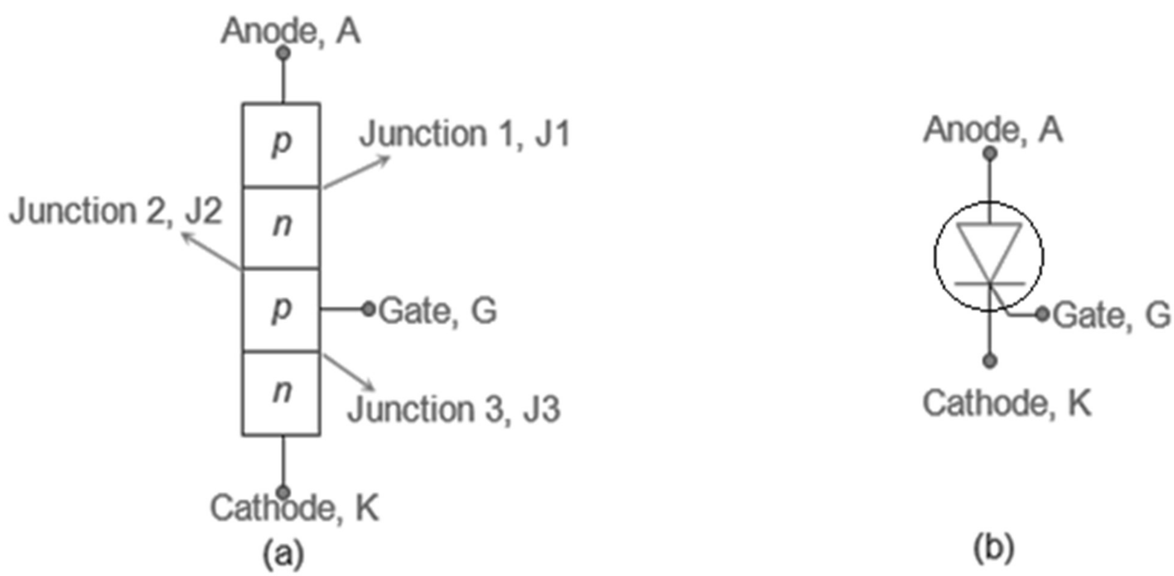

Fig:5.2.1 (a) SCR Construction (b) SCR Symbol

These SCRs can be considered equivalent to two inter-connected transistors

Here it is seen that a single SCR is equal to a combination of pnp (Q1) and npn (Q2) transistors where the emitter of Q1 will act as the anode terminal of the SCR while the emitter of Q2 will be its cathode. Further, the base of Q1 is connected to the collector of Q2 and the collector of Q1 is shorted with the base of Q2 to result in the gate terminal of the SCR.

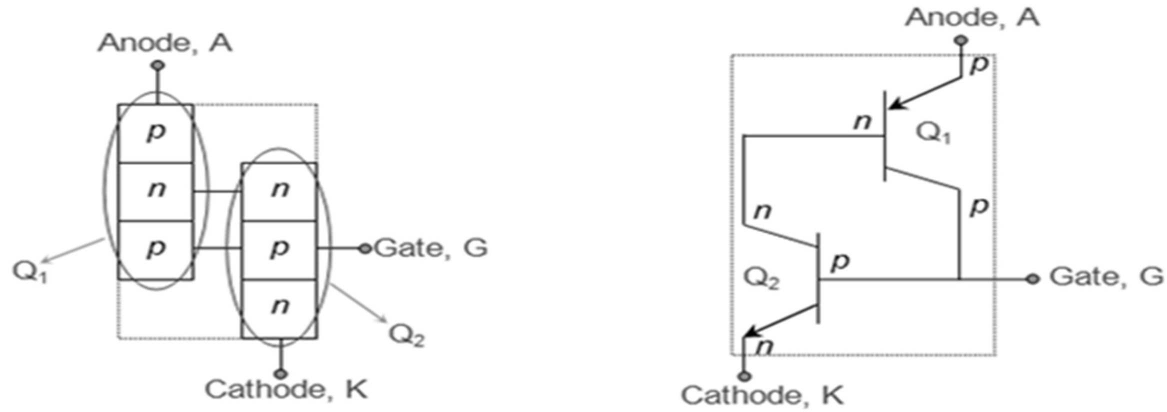

Fig:5.2.2 SCR Realization interms of BJT

The working of SCR can be understood by analyzing its behaviour in the following modes:

1. **Reverse Blocking Mode:** In this mode, the SCR is reverse biased by connecting its Anode terminal to negative end of the battery and by providing its Cathode terminal with a positive voltage. This leads to the reverse biasing of the junctions J1 and J3, which inturn prohibits the flow of current through the device, inspite of the fact that the junction J2 will be forward biased. Further, in this state, the SCR behaviour will be identical to that of a typical diode as it exhibits both the flow of reverse saturation current as well as the reverse break-down phenomenon.

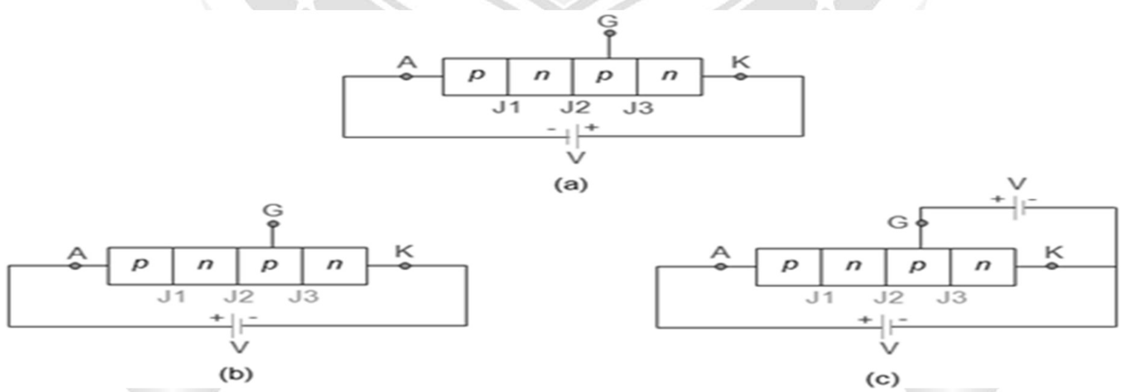

Fig:5.2.3 Biasing of Silicon Controlled Rectifier

2. **Forward Blocking Mode:** Here a positive bias is applied to the SCR by connecting its Anode to the positive of the battery and by shorting the SCR cathode to the battery's negative terminal, as shown by Figure 3b. Under this condition, the junctions J1 and J3 gets forward biased while J2 will be reverse biased which allows only a minute amount of current flow through the device.

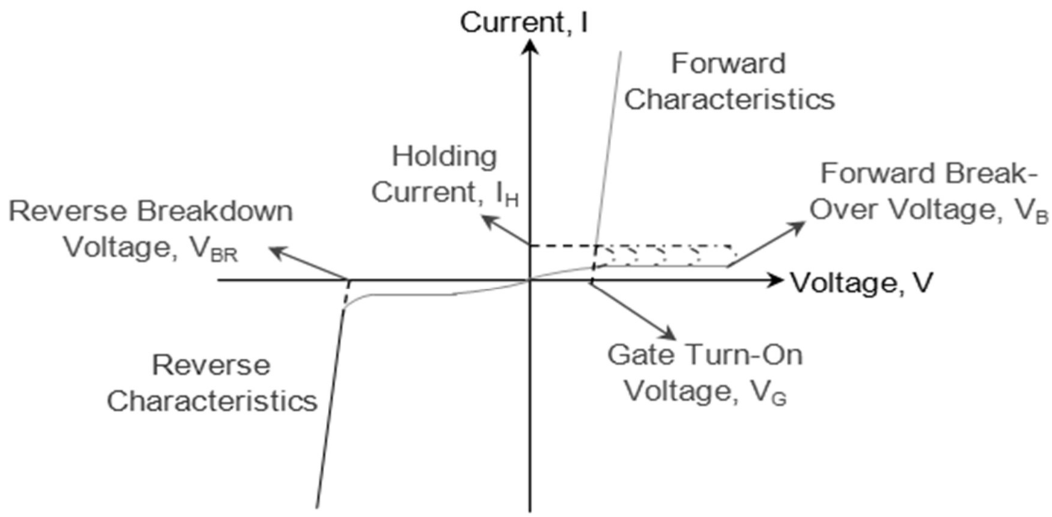

Fig:5.2.4 (a) SCR Construction (b) SCR Symbol

3. **Forward Conduction Mode:** SCR can be made to conduct either (i) By Increasing the positive voltage applied between the Anode and Cathode terminals beyond the Break-Over Voltage, VB or (ii) By applying positive voltage at its gate terminal as shown by Figure 3c. In the first case, the increase in the applied bias causes the initially reverse biased junction J2 to break-down at the point corresponding to Forward Break-Over Voltage, VB. This results in the sudden increase in the current flowing through the SCR as shown by the pink curve in Figure 4, although the gate terminal of the SCR remains unbiased.

However SCRs can be made to turn-on at a much smaller voltage level by proving small positive voltage between the gate and the cathode terminals. The reason behind this can be better understood by considering the transistor equivalent circuit of the SCR. Here it is seen that on applying positive voltage at the gate terminal, transistor Q2 switches ON and its collector current flows into the base of transistor Q1. This causes Q1 to switch ON which in turn results in the flow of its collector current into the base of Q2. This causes either transistor to get saturated at a very rapid rate and the action cannot be stopped even by removing the bias applied at the gate terminal, provided the current through the SCR is greater than that of the Latching current. Here the latching current is defined as the minimum current required to maintain the SCR in conducting state even after the gate pulse is removed.

In such state, the SCR is said to be latched and there will be no means to limit the current through the device, unless by using an external impedance in the circuit. This necessitates one to resort for different techniques like Natural Commutation, Forced Commutation or Reverse Bias Turn-Off and Gate Turn-Off to switch OFF the SCR. Basically all of these techniques aim at reducing the Anode Current below the Holding Current, the minimum current which is to be maintained through the SCR to keep it in its conducting mode. Similar to turn-off techniques, there also exist different turn-on techniques for the SCR like Triggering by DC Gate Signal, Triggering by AC Gate Signal and Triggering by Pulsed Gate Signal, Forward-Voltage Triggering, Gate Triggering, dv/dt Triggering, Temperature Triggering and Light Triggering.

There are many variations of SCR devices viz., Reverse Conducting Thyristor (RCT), Gate Turn-Off Thyristor (GTO), Gate Assisted Turn-Off Thyristor (GATT), Asymmetric Thyristor, Static Induction Thyristors (SITH), MOS Controlled Thyristors (MCT), Light Activated Thyristors (LASCR) etc. Normally SCRs have high switching speed and can handle heavy current flow.

Application of SCR

1. Power switching circuits (for both AC and DC)
2. Zero-voltage switching circuits
3. Over voltage protection circuits
4. Controlled Rectifiers
5. Inverters
6. Battery Charging Regulator
7. Latching Relays
8. Computer Logic Circuits
9. Remote Switching Units
10. Phase Angle Triggered Controllers
11. Timing Circuits
12. IC Triggering Circuits
13. Welding Machine Control
14. Temperature Control Systems