Silicon Controlled Rectifier

Silicon Controlled Rectifier (SCR) is a very important member of the family of four layer pnpn devices. Some of the other members of the family are Shockley Diodes, Silicon Controlled Switch, Triac, Diac, etc. All these devices are capable of handling large currents, and hence they are rapidly taking the status of essential components in industrial applications. The application areas of SCR include relay controls, regulated power supplies, motor controls, invertors, battery chargers, protection circuits, heater controls, etc.

The SCR is a three terminal, three junction device. The three terminals are called Anode, Cathode and Gate as shown in Fig. 1. The figure also shows the three junctions and circuit symbol of the device. The operation of SCR can be understood by splitting the four layer pnpn structure into two three layer transistor structures as shown in figure 2 (a) and then analyzing the resultant of Fig. 2 (b).

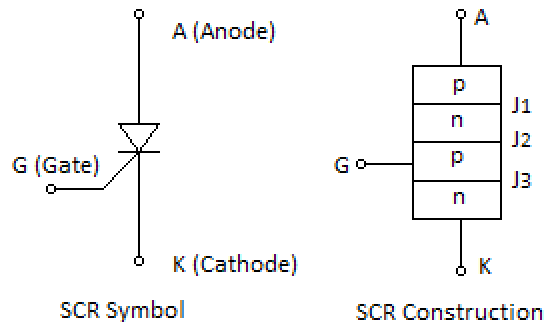

Figure 1

Note that one transistor is pnp while the other is npn. These two transistors form a feedback circuit. Let us first consider the case where the gate is at zero potential with respect to the cathode and a positive potential is applied to the anode.

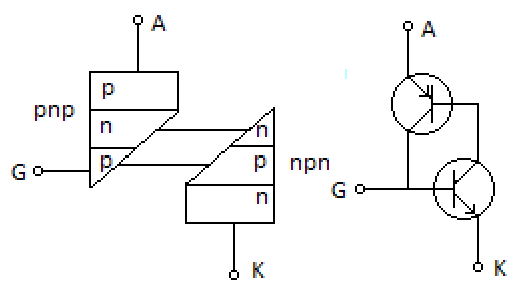

Figure 2

V_{BE2} = Base emitter voltage of transistor Q2 = V_{AK} = 0.

So $I_{B2} = 0$ and $I_{C2} \cong I_{CO}$

The base current of transistor Q_1 is $I_{B1} = I_{C2} \cong I_{CO}$ which is too strong to turn Q_1 ON. Both transistors are therefore in the OFF state and the anode current $I_A = I_{CO}$. This represints the OFF state of the SCR. Another explanation can be given this way. Junctions J_1 and J_3 are forward biased J_2 is reverse biased. Hence very little reverse current (I_{CO}) can flow from anode to cathode.

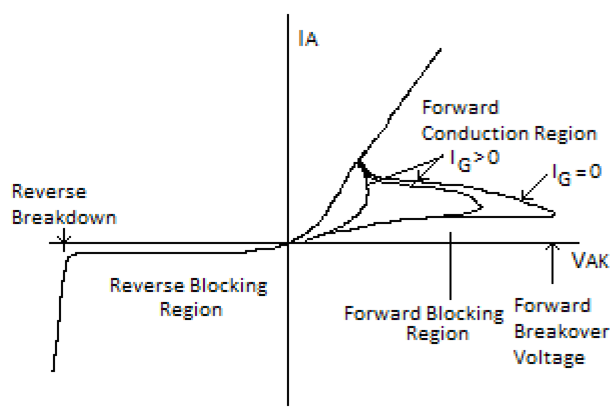

Figure 3

If the anode to cathode voltage is raised to a very high value called the forwards breakover voltage V_{BrFo} , then the junction J_2 breaks over and a large current, that is restricted by an external load only, flows. This is the ON state of the SCR indicated as the forward conduction region in figure 3. In this state the anode to cathode resistance of the SCR becomes very small and the SCR acts as a closed switch. In such a situation almost the whole of the source voltage appears across the external load connected in series with the SCR. The function of the gate is to decide the anode to cathode voltage at which the forward breakover will take place. The value of forward breakover voltage (V_{brFo}) can be controlled by the magnitude of gate current.

A SCR is a negative resistance device. This can be seen in its characteristic curve.In the portion of the curve just above the forward blocking region, I_A decreases with increase in V_{AK}. In this region dV/dI whch is the dynamic resistance, is negative. The negative resistance gives rise to several properties including its switching behavior. If you fix V_{AK} at a particular value less than forward breakover voltage, then if there is zero gate current, there is very little anode current I_A. Now, if you gradually increase I_G, then at a certain value of I_G, there will be a sudden increase in I_A. Once this happens, then even if you decrease I_G to zero, the forward conduction will continue. This conduction will stop only if I_A is brought below a threshold value. Thus SCR acts as a switch which turns I_A ON by help of I_G but after that it cannot be switched off through I_G. It switches OFF only when I_A decreases below its threshold value.