

# THYRISTORS - AN INTRODUCTION

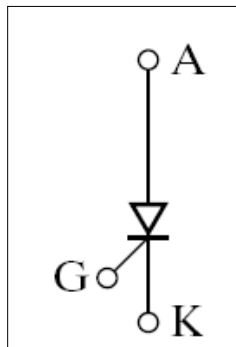
A thyristor is the most important type of power semiconductor devices. They are extensively used in power electronic circuits. They are operated as bi-stable switches from non-conducting to conducting state.

A thyristor is a four layer, semiconductor of p-n-p-n structure with three p-n junctions. It has three terminals, the anode, cathode and the gate.

The word thyristor is coined from thyatron and transistor. It was invented in the year 1957 at Bell Labs. The Different types of Thyristors are

- Silicon Controlled Rectifier (SCR).
- TRIAC
- DIAC
- Gate Turn Off Thyristor (GTO)

## 3.1 Silicon Controlled Rectifier (SCR)



The SCR is a four layer three terminal device with junctions  $J_1, J_2, J_3$  as shown. The construction of SCR shows that the gate terminal is kept nearer the cathode. The approximate thickness of each layer and doping densities are as indicated in the figure. In terms of their lateral dimensions Thyristors are the largest semiconductor devices made. A complete silicon wafer as large as ten centimeter in diameter may be used to make a single high power thyristor.

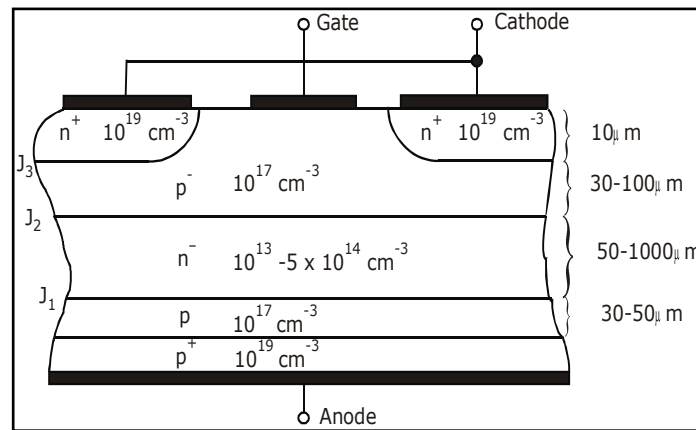


Fig.3.1: Structure of a generic thyristor

### Qualitative Analysis

When the anode is made positive with respect to the cathode junctions  $J_1$  &  $J_3$  are forward biased and junction  $J_2$  is reverse biased. With anode to cathode voltage  $V_{AK}$  being small, only leakage current flows through the device. The SCR is then said to be in the forward blocking state. If  $V_{AK}$  is further increased to a large value, the reverse biased junction  $J_2$  will breakdown due to avalanche effect resulting in a large current through the device. The voltage at which this phenomenon occurs is called the forward breakdown voltage  $V_{BO}$ . Since the other junctions  $J_1$  &  $J_3$  are already forward biased, there will be free movement of carriers across all three junctions resulting in a large forward anode current. Once the SCR is switched on, the voltage drop across it is very small, typically 1 to 1.5V. The anode current is limited only by the external impedance present in the circuit.

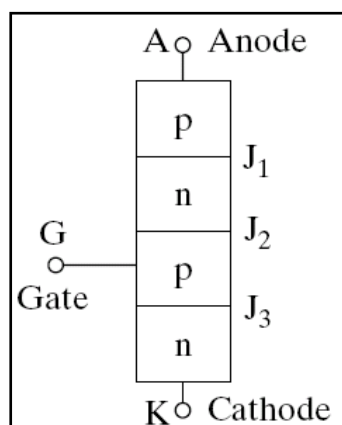


Fig.3.2: Simplified model of a thyristor

Although an SCR can be turned on by increasing the forward voltage beyond  $V_{BO}$ , in practice, the forward voltage is maintained well below  $V_{BO}$  and the SCR is turned on by applying a positive voltage between gate and cathode. With the application of positive gate voltage, the

leakage current through the junction  $J_2$  is increased. This is because the resulting gate current consists mainly of electron flow from cathode to gate. Since the bottom end layer is heavily doped as compared to the p-layer, due to the applied voltage, some of these electrons reach junction  $J_2$  and add to the minority carrier concentration in the p-layer. This raises the reverse leakage current and results in breakdown of junction  $J_2$  even though the applied forward voltage is less than the breakdown voltage  $V_{BO}$ . With increase in gate current breakdown occurs earlier.

Source : <http://elearningatria.files.wordpress.com/2013/10/ece-vii-power-electronics-10ec73-notes.pdf>