Introduction

• The control of electric motor drives requires control of electric power.
• Power electronics have eased the concept of power control.
• Power electronics signifies the word power electronics and control or we can say the electronic that deal with power equipment for power control.
- Power electronics based on the switching of power semiconductor devices.
- With the development of power semiconductor technology, the power handling capabilities and switching speed of power devices have been improved tremendously.
Power Semiconductor Devices

• The first SCR (The Silicon-Controlled Rectifier) was developed in late 1957.
• Power semiconductor devices are broadly categorized into 3 types:
  – 1. Power diodes (600V, 4500A)
  – 2. Transistors
  – 3. Thyristors (10KV, 300A, 30MW)

* A Silicon-Controlled Rectifier, or SCR, is essentially a Shockley diode with an extra terminal added. This extra terminal is called the gate, and it is used to trigger the device into conduction (latch it) by the application of a small voltage.

Thyristors

• Thyristor is a four layer three junction pnpn semiconductor switching device.
• It has 3 terminals these are anode, cathode and gate.
• SCRs (The Silicon-Controlled Rectifier) are solid state device, so they are compact, possess high reliability and have low loss.
- SCR is made up of silicon, it act as a rectifier; it has very low resistance in the forward direction and high resistance in the reverse direction.
- It is a unidirectional device.

- **Static V-I characteristics of a Thyristor**
  - Anode and cathode are connected to main source voltage through the load. The gate and cathode are fed from source $E_S$. 

![Diagram of Thyristor](image)
A typical SCR V-I characteristic is as shown below:

- It can be inferred from the static V-I characteristic of SCR.
- SCR have 3 modes of operation:
  - 1. Reverse blocking mode
  - 2. Forward blocking mode (off state)
  - 3. Forward conduction mode (on state)
• **Reverse Blocking Mode**
  
  • When cathode of the thyristor is made positive with respect to anode with switch open thyristor is reverse biased.
  • Junctions $J1$ and $J3$ are reverse biased where junction $J2$ is forward biased.
  • The device behaves as if two diodes are connected in series with reverse voltage applied across them.

  ![Diagram of Reverse Blocking Mode](image)

• A small leakage current of the order of few mA only flows.
• As the thyristor is reverse biased and in blocking mode.
• It is called as acting in reverse blocking mode of operation.
• Now if the reverse voltage is increased, at a critical breakdown level called reverse breakdown voltage $VBR$, an avalanche occurs at $J1$ and $J3$ and the reverse current increases rapidly.
• As a large current associated with $VBR$ and hence more losses to the SCR.
• This results in Thyristor damage as junction temperature may exceed its maximum temperature rise.

- Forward Blocking Mode
- When anode is positive with respect to cathode, with gate circuit open, thyristor is said to be forward biased.
- Thus junction J1 and J3 are forward biased and J2 is reverse biased.
- As the forward voltage is increases junction J2 will have an avalanche breakdown at a voltage called forward breakover voltage $V_{BO}$. 
• When forward voltage is less than $V_{BO}$ thyristor offers high impedance.
• Thus a thyristor acts as an open switch in forward blocking mode.

Forward Conduction Mode
• Here thyristor conducts current from anode to cathode with a very small voltage drop across it.
• So a thyristor can be brought from forward blocking mode to forward conducting mode:
  • 1. By exceeding the forward breakover voltage.
  • 2. By applying a gate pulse between gate and cathode.
• During forward conduction mode of operation thyristor is in on state and behave like a close switch.
• Voltage drop is of the order of 1 to 2mV.
• This small voltage drop is due to ohmic drop across the four layers of the device.