Unit 4: Protection of Power Semiconductor Devices

Module 11: Overvoltage protection, Overcurrent protection, Overtemperature protection

Introduction to protection of power semiconductor devices

Power electronic devices operate from the supply of utility power. And the utility power may contain disturbances. Therefore, protection of power devices and converters exposed to the disturbances associated with it. And also, these devices and converters associated with the transient as well as the fault at the load side. So, to protect the power electronics switches (devices) and converter, several protection schemes must be integrated into a converter.

There are many techniques developed for the Protection of power devices and converters. Some of the protection schemes are common for all devices and converters. Even so, differences in essential features of devices need special protection schemes particular for those devices.

Various schemes for protection of power semiconductor devices(SCR)

1. Over voltage Protection
2. Over Current Protection
3. Over Temperature
4. di/dt Protection
5. dv/dt Protection
6. Electro-static discharge

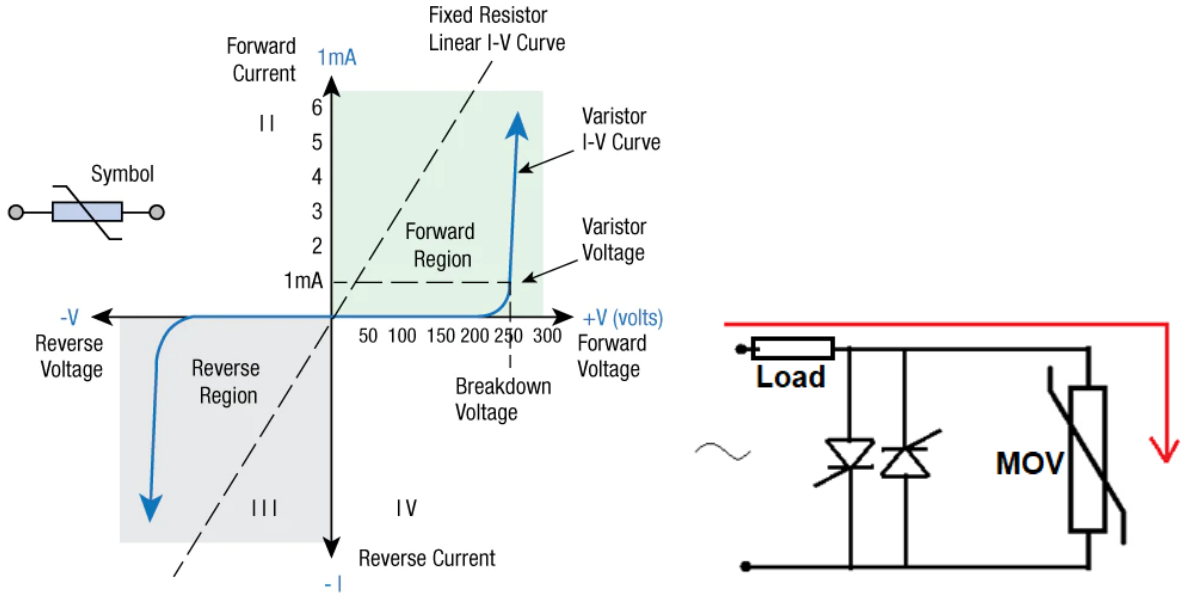
Sources of Overvoltage conditions

1. Lightning Surges
2. Transformer switching
3. Thyristor turn-off
4. Load switching

Protective Measure for Over-voltages

The effect of over-voltages can be minimized by using non-linear resistors such as metal oxide varistors(MOV)

During normal voltage operation the MOV offers very high resistance and acts as if it is not present in the circuit. However when overvoltage occurs, its resistance decreases and it behaves as a short circuit path thus protecting the SCR.



The most common type of varistor is the metal-oxide varistor (MOV) that contains a ceramic mass of zinc oxide grains, in a matrix of other metal oxides sandwiched between two electrodes). The boundary between each grain and its neighbour forms a diode-like junction, which allows current to flow in only one direction. When a small or moderate voltage is applied across the electrodes, only a tiny current flow, caused by reverse leakage through the diode junctions. When a large voltage is applied, the diode junction breaks down due to a combination of thermionic emission and electron tunnelling, and a large current flow. The result of this behaviour is a highly nonlinear current-voltage characteristic, in which the MOV has a high resistance at low voltages and a low resistance at high voltages.

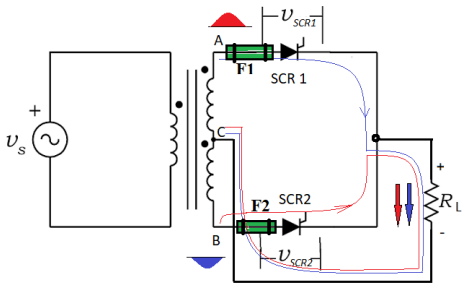
Over current Protection

Causes of Overcurrent

- Overcurrent is any current load in excess of the safety rating of device.
- Some of the causes for overcurrent include short circuits, excessive load, incorrect design, various faults in the circuit or a ground fault.
- Over currents may damage semiconductor devices, due to the junction temperature exceeding the rated value.

Over-current Protection

Protective Measure:



- SCR can be protected from over current by using CB(Circuit Breakers) and fast acting current limiting fuses (FACLF).
- CB are used for protection of thyristor against continuous overloads or against surge currents of long duration as a CB has long tripping time.
- Fast-acting fuse is used for protecting SCR against high surge current of very short duration.

Over-temperature - causes

- The On-state conduction
- Off-state leakage current and
- Switching losses

Generate heat in power semiconductor devices.

This heat must be transferred from the device to the atmosphere to maintain the junction temperature within the specified range.

Over-temperature Protection: Heat sink

- Heat transfer may be accomplished by conduction, convection and radiation, convection cooling is most commonly used in power applications.
- This can be achieved by mounting the thyristor on heat sink which is mainly made by high thermal conductivity metals like aluminium (Al), copper (Cu) etc. Mainly aluminium (Al) is used due to its low cost.
- For better cooling the contact area, between the device and the heat sink should be flat, smooth and free from dirt and corrosion.
- There are several types of mounting techniques for SCR such as Lead-mounting, stud-mounting, Bolt-down mounting, press-fit mounting, press-pack mounting etc.

Over-temperature Protection: water/oil cooling

- In very high power application, the devices are cooled either by oil or by water.
- Water-cooling is more efficient and approximately 3 times more effective than oil cooling.

- It is necessary to use distilled water to minimize corrosion, and antifreeze to avoid freezing,
- Oil cooling provides great insulation and eliminated the problems of corrosion and freezing, but has limited applications.