Protection of Thyristors.

For satisfactory and reliable operation of thyristor, we need to protect it from various abnormal conditions.

A thyristor must be provided following protection, in order to obtain reliable operation.

1. Over-current Protection.
2. Over-voltage Protection.
3. High $\frac{di}{dt}$ protection.
4. High $\frac{dv}{dt}$ protection.
5. Thermal protection.
6. Gate protection
   - ⓐ Over-current protection in gate
   - ⓑ Over-voltage protection in gate
   - ⓒ Protection against noise signals in gate

① Over-Current Protection of Thyristors.

- Over-current may be caused because of faults, short-circuits, or surge currents due to lightning strike.
- This kind of overcurrent may lead to damage of thyristors, due to the junction temperature exceeding its rated value.

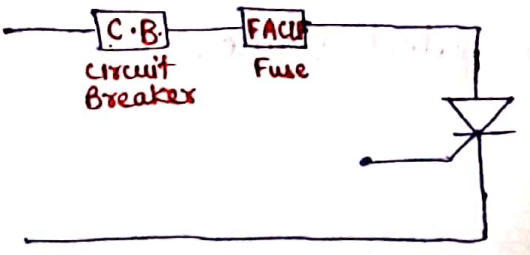
- Overcurrent protection in thyristor circuits is achieved by use of
  - (a) Circuit Breaker
  - (b) Fast-acting fuses.
- The protection mechanism must isolate the faulty part of the circuit, before any damage is done to the SCR because of fault.

Use of circuit breakers :-

- Circuit breakers are used for protecting SCRs from surge current or fault current of long duration.
- circuit breakers have longer tripping time.

Use of Fast acting, current-limiting fuses :-

- It is used for protecting SCRs, from large surge currents of very short duration.
- In order that the fuse protects the thyristor reliably, the I^2t rating of the fuse must be less than that of the SCR.



② Over-voltage Protection of Thyristors.

- Over-voltage transients are one of the main causes of failure of thyristors.

- Over-voltage may cause unwanted turn-on of a thyristor or permanent damage to the device.

- There are two reasons for over-voltages.

(i) Internal causes for over-voltages.

↳ Over-voltage generated during commutation of a thyristor.

⇓

Large $\frac{di}{dt}$ during commutation, causes Large transient voltage $L\frac{di}{dt}$

(ii) External causes of over-voltages.

(a) Due to interruption of current in an inductive circuit.

(b) Due to lightning strike on feeder lines

(c) Due to energizing or de-energizing of primary of transformer connected in the circuit.

- Over-voltage protection of thyristors is achieved by use of.
  - (a) Voltage Snubber Circuit or RC circuits.
  - (b) Voltage Clamping devices or Non-linear resistors.

- Use of snubber circuit or RC circuits.
  - Voltage snubber circuit or RC circuit is connected across the device to be protected
  - Snubber circuit provides two protection
    - ↳ Over-voltage protection
    - ↳ $\frac{dv}{dt}$ protection.
  - Snubber circuit provides a local path for reverse recovery current, thus reducing internal over-voltages.

- Use of voltage-clamping device or Non-linear resistors.
  - A voltage-clamping device is a non-linear resistor. It is also known as Varistor.
  - For a non-linear resistor, resistance value decreases with increasing voltage.
  - So, a non-linear resistor or varistor is connected across SCR to protect it from over-voltage.

Under normal condition.

↳ Voltage is within limits ⇒ So, resistance is high

⇓

So, it only allows very small current.

When over-voltage occurs.

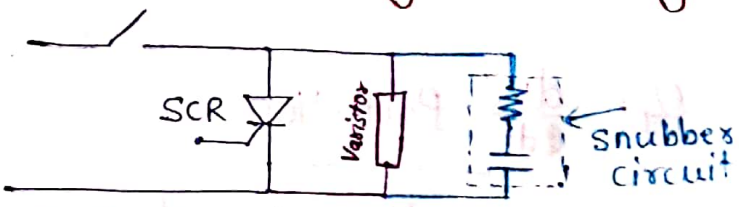
↳ When surge voltage appears ⇒ the device resistance decreases

⇓

It almost creates a short-circuit path across SCR. Thus only a small voltage appears across SCR.

- Eg. - Selenium thyrector diodes, Metal-oxide varistors] → Used for over-voltage protection of SCRs.

→ Generally, for protection of SCR against over-voltages, both snubber circuit as well as voltage clamping device are used.



(3) High $\frac{di}{dt}$ protection of SCRs.

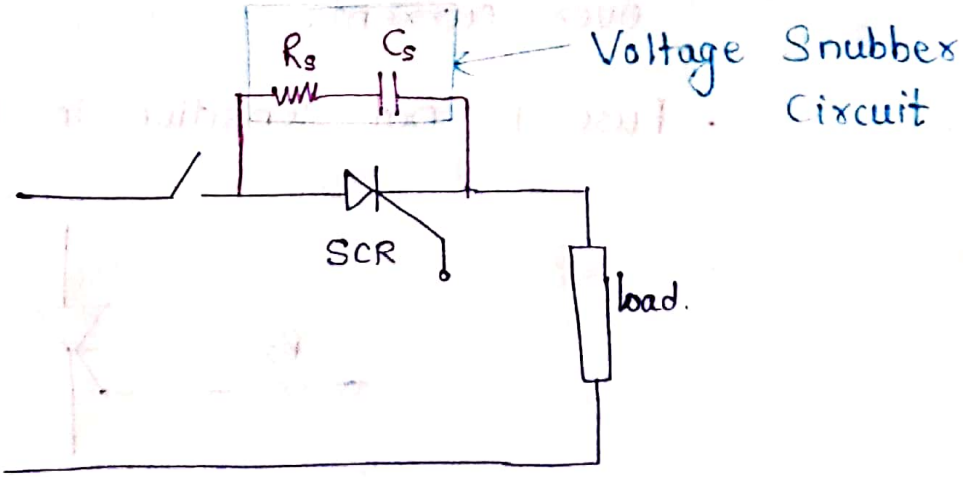
- When we turn-on a thyristor, the anode current rises from zero, to its peak value.
- Also, we know that, initially after turning on, the anode current passes through a small area near gate-cathode junction and slowly spreads to whole area of junction.

- Voltage across C_s, builds up slowly. So, $\frac{dV}{dt}$ across C_s is less than the specified maximum $\frac{dV}{dt}$ rating of the device.

- **Purpose of connecting "R_s" in the snubber circuit.**

  - C_s is enough to protect SCR against high $\frac{dV}{dt}$, then why are we connecting R_s in series with C_s.

  - R_s is connected to limit the current in the circuit, due to sudden discharge of the capacitor when SCR is turned-on. In absence of R_s, high discharge current of ~~SCR~~ capacitor may destroy the SCR.



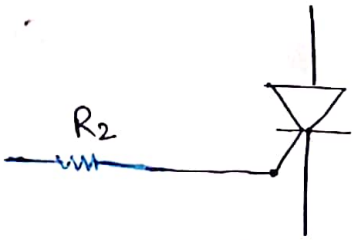
⑤ Thermal Protection.

- Heat sinks are used to dissipiate the heat produced during operation of SCRs.
- Without using heat sinks, temperature of SCRs may rise above the rated thermal limit, and may damage the SCRs.

⑥ Gate Protection

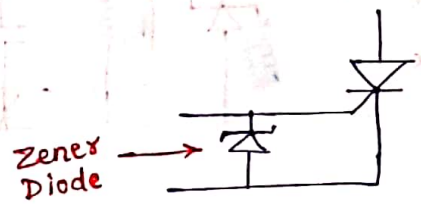
ⓐ Over-current protection in Gate

- Overcurrent in the gate circuit may raise junction temperature beyond specified limit, leading to its damage.
- Range of current in gate circuit is small.
- So, **a resistor**, connected in series with gate circuit is sufficient to limit over-current.
- Fuse is not sensitive in this case.



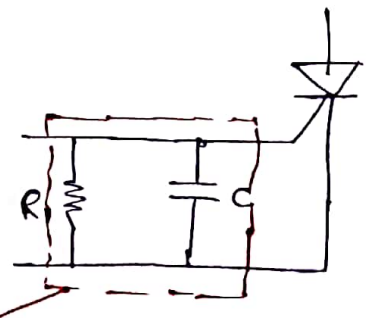
(b) Over voltage Protection in Gate

- Over-voltage across the gate circuit can also cause false triggering of SCRs.
- Varistors are NOT used in the gate circuit to protect from over voltages as it is not sensitive to such small voltage.
- So, zener diode is used to limit voltage level in gate circuit. It is connected across gate circuit.



(c) Protection against noise signals in Gate

- The noise or unwanted signals in gate circuit may lead to false triggering of the SCR.
- These noise signals must be diverted before ~~without passing~~ they pass through the gate terminals.
- A parallel connected R-C Circuit is connected across gate and cathode to bypass noise signals.



RC circuit to filter out noise.

Complete representation of SCR protection scheme