① Series operation of SCRs.

Ideal condition :-

↳ All the SCRs connected in series have same rating and identical characteristics. Due to identical characteristics, they share equal voltage.

Practical condition :-

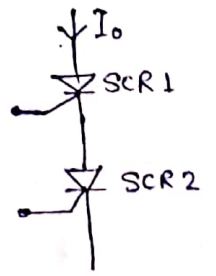
↳ However, practically the situation is different. Even when SCRs have same rating, their characteristics differ and hence voltage shared by each SCR is not equal.

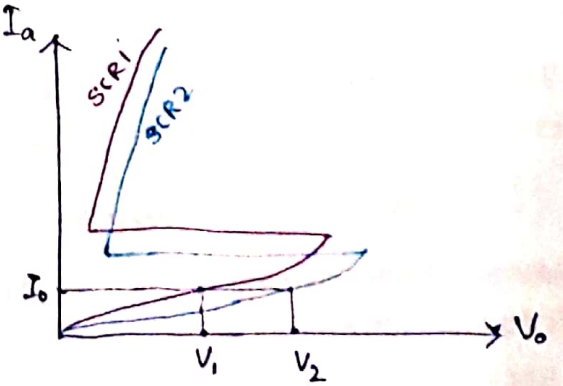
∵ Problem related to series connected SCRs ⇒ Unequal sharing of voltages.

- There are different reasons for this problem of unequal sharing of voltages.

Reason 1 :-

↳ Due to difference in forward blocking characteristics of series connected SCRs.





- Under forward blocking mode, same leakage current I_o flows through both SCRs, but the voltage blocked by them differs due to difference in characteristics.

Solution

↓

Use of static equalising circuit.

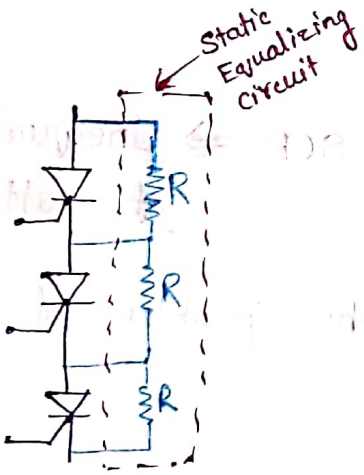
- So, the two SCRs take a total voltage of $V_1 + V_2$, instead of $2V_2$.

- This problem is overcome by static equalizing circuit, which consists of shunt resistance R, connected across each SCR.

- Magnitude of this shunt resistance is given by

$$R = \frac{n V_{bm} - V_s}{(n-1)\Delta I_b}$$

Here,



V_{bm} → Maximum permissible blocking voltage of each SCR.

V_s → String voltage.

ΔI_b → $I_{bmx} - I_{bm}$

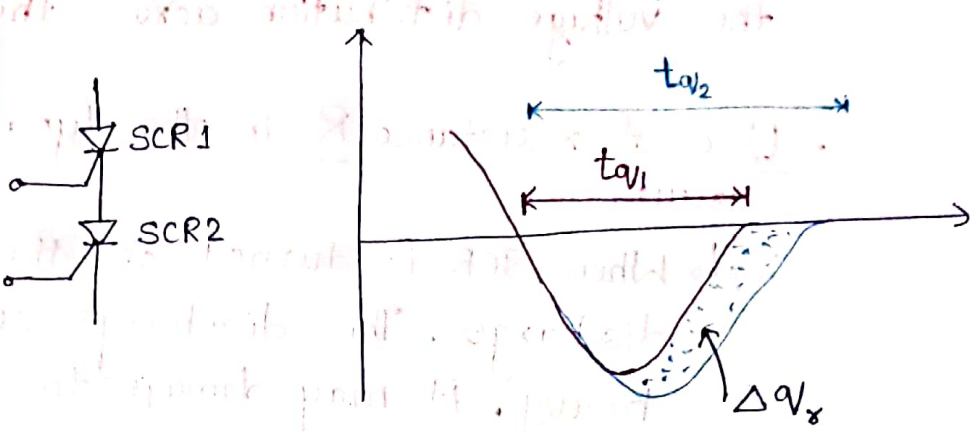
↓

Difference between maximum and minimum blocking current or leakage current.

n → No. of SCRs in a string.

Reason 2

↳ Due to difference in reverse recovery characteristics (Switching characteristics).



- Voltage unbalance may appear across SCRs connected in series, during turn-off process, due to difference in reverse recovery characteristics.

- If both the SCRs have same reverse recovery characteristics, then they turn off simultaneously. So, they will share the total voltage equally.

- But if SCR1 has shorter - reverse recovery time then it will turn-off first. SCR2 takes longer time to turn-off. So, all the supply voltage appears across SCR1 only.

- So, during turn-off process, different voltage may appear across the SCRs. This is overcome by use of dynamic equalizing circuit. It consists of a capacitor 'C' ~~connected across SCR~~. and a resistor in series with capacitor. The whole arrangement is connected across the SCR.

Solution

↓

Use of dynamic equalizing circuit.

- The difference in reverse recovery charge of both SCRs, ΔQ_R, induces a voltage in the capacitor, which ultimately tends to equalise the voltage distribution across the SCRs.

- Use of resistance 'R' in the dynamic equalizing circuit.
  - ↳ When SCR is turned on, the capacitor discharges. This discharge current is heavy. It may damage the SCR. So, to limit the discharge current of capacitor, resistance is used in the dynamic equalizing circuit.

- Use of 'Diode' in the dynamic equalizing circuit.
  - Due to presence of resistance in the dynamic equalising circuit, the charging time of capacitor may increase. This will reduce the effectiveness of capacitor in equalizing the voltage.
  - So, a diode is used to bypass the resistor during charging time of capacitor.

- Value of capacitor, to be used in dynamic equalizing circuit is found using.

$$C = \frac{(n-1)\Delta Q_R}{n V_{bm} - V_s}$$

ΔQ_R → diff. in stored charge

V_{bm} → Maximum permissible blocking voltage of each SCR.

n → No. of SCR in string.

V_s → Source voltage

So, 'Equalizing Circuits for Series connected SCRs. is as shown below.