VIVEKANANDA COLLEGE
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NAAC ACCREDITED 'A' GRADE

Topic: thyristor

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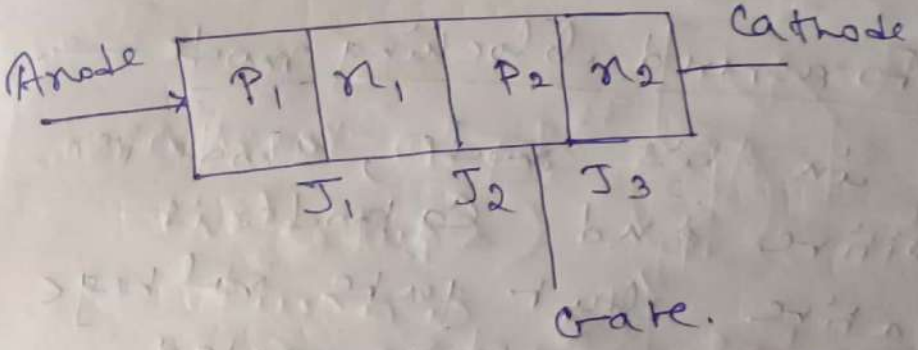
Semiconductor Controlled Rectifier

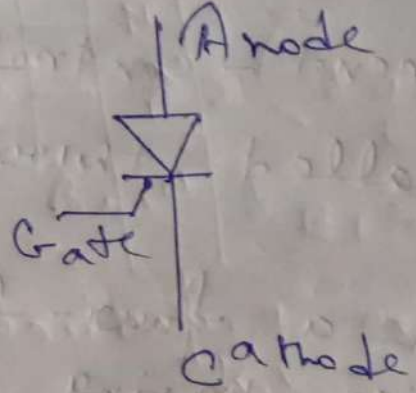
SCR (semiconductor controlled Rectifier or silicon controlled Rectifier) is a four-layer state current-controlling device SCR also called thyristor.

It is a four-layerd P-n-p-n device having three p-n junction, J_1, J_2, J_3 in series.



The n_1 layer is much wider than other regions and it has lowest doping level for high Break-down voltage. The contact electrode to outer p-layer is called anode and outer n-layer is called cathode. The gate electrode is connected to inner p-layer.

The three terminal device is commonly called SCR. An SCR is diagramatically represented by →



Modes of operation in SCR

(1) Forward blocking mode —

in this mode, anode is positive and Cathode is negative but gate voltage is zero or disconnected. So Junction J_1, J_3 → forward bias and J_2 reverse bias. If reverse bias voltage of J_2 increase after avalanche value it starts to conduct. But Below this value, SCR in off state.

ii) Forward conducting mode —

An SCR is brought to on state by increasing potential difference between anode and cathode or by applying a positive signal at gate. After on state, Gate voltage is no longer needed to maintain.

SCR can be switched off by →

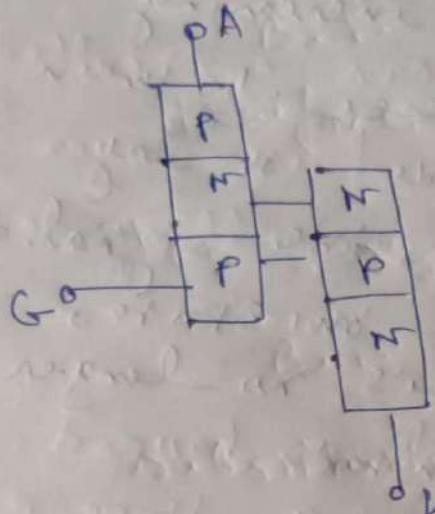
i) Decreasing anode current below the lowest value called holding current.

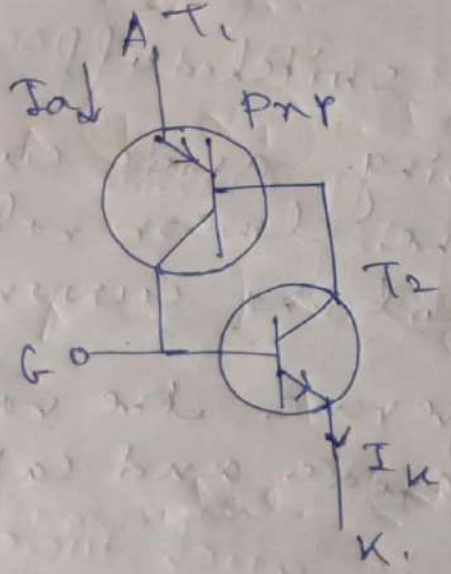
ii) By reverse the voltage of anode and cathode.

iii) Reverse blocking mode :—

In this mode, Cathode is made positive w.r.t. to anode. Then J_1, J_3 — reverse biased and J_2 is forward biased. In this mode, a small leakage current flows through it

Two transistor Analogy of SCR :-





Two transistor equivalent circuit.

The collector of each transistor is connected to the base of the other.

Assume, load resistance is connected between anode and cathode and small voltage is applied at gate. when there is no gate voltage the T2 is in cut-off

and no current flows through collector and hence Base of T_1.

When a particular voltage is applied between gate and Cathode, a small base current flows through the base of T_2 and I_C increase. And hence I_B at T_1 drives the transistor into saturation and I will flow from anode to Cathode.

$I_{B2} = I_{C1}$ and $I_{C2} = I_{B1}$

Current through cathode

$$I_K = I_G + I_A \quad \text{---} (1)$$

$$I_{B1} = I_{E1} - I_{C1} \quad \text{---} (2)$$

and $$I_{C1} = \alpha_1 I_{E1} + I_{CO1} \quad \text{---} (3)$$

I_{CO} — leakage current.

Substitute eq. 3 in eq. 2.

$$I_{B1} = I_{E1}(1 - \alpha_1) - I_{CO1} \quad \text{---} 4$$

The emitter I of T_1

$$I_A = I_{E1}$$

$$I_{B1} = I_A (1 - \alpha_1) - I_{CO1}$$

For T_2

$I_{C2} = \alpha_2 I_{E2} + I_{CO2}$

But $I_K = I_{e2}$

Therefore $I_{C2} = \alpha_2 I_K + I_{CO2}$

$I_{C2} = \alpha_2 (I_g + I_A) + I_{CO2}$ — (5)

But $I_{B1} = I_{C2}$ — (6)

substituting eq 4 and 5 in eq. 6.

$I_A (1 - \alpha_1) - I_{CO1} = \alpha_2 (I_g + I_A) + I_{CO2}$

$I_A = \frac{[\alpha_2 I_g + I_{CO1} + I_{CO2}]}{1 - (\alpha_1 + \alpha_2)}$

when $(\alpha_1 + \alpha_2) < 1$

when $(\alpha_1 + \alpha_2) = 1$ then device goes to more conducting state to conducting state.