Republic of Iraq Ministry of Higher
Education and Scientific Research
Ashur University
Department of Medical Instrumentation
Technical Engineering College



POWER ELECTRONIC

Turn On ,turn Off methods or SCR Triggering Methods and base drive circuit

يتبع المحاضرة الثالثة

م. جبار قاسم فهد

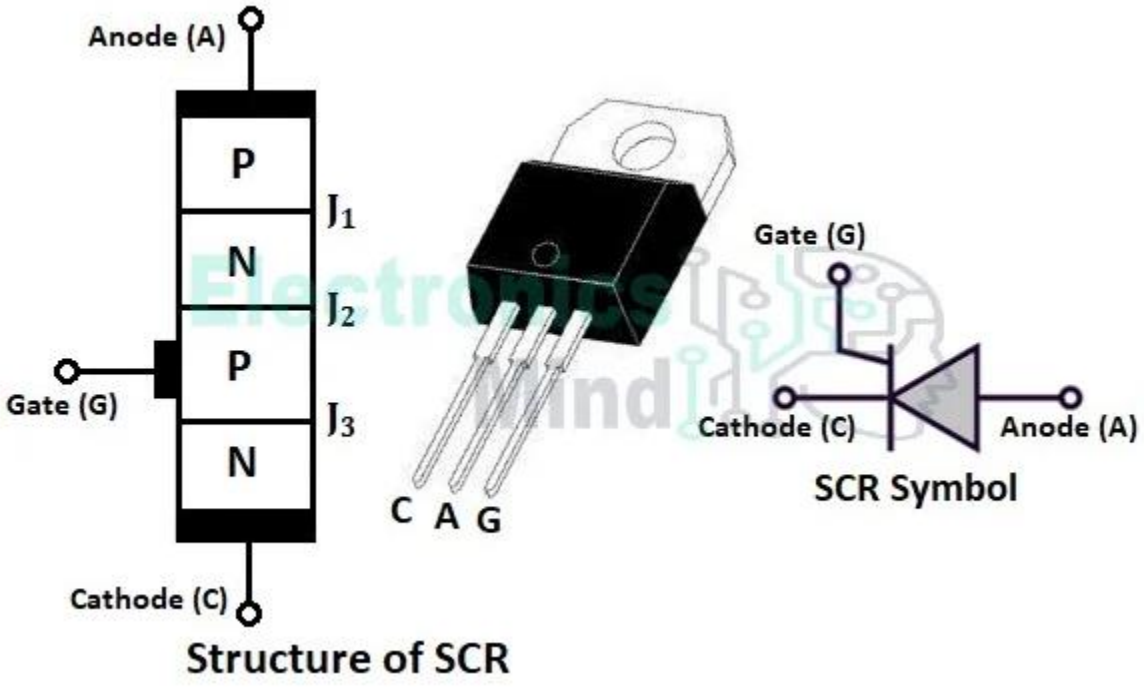
2023-2024

Methods of triggering a thyristor(Turn On Methods of SCR)ا

طرق اشعال الثايرستر

Triggering:-

The turning on Process of the SCR is known as Triggering. In other words, turning the SCR from Forward-Blocking state to Forward-Conduction state is known as Triggering.The various methods of SCR triggering are discussed here.

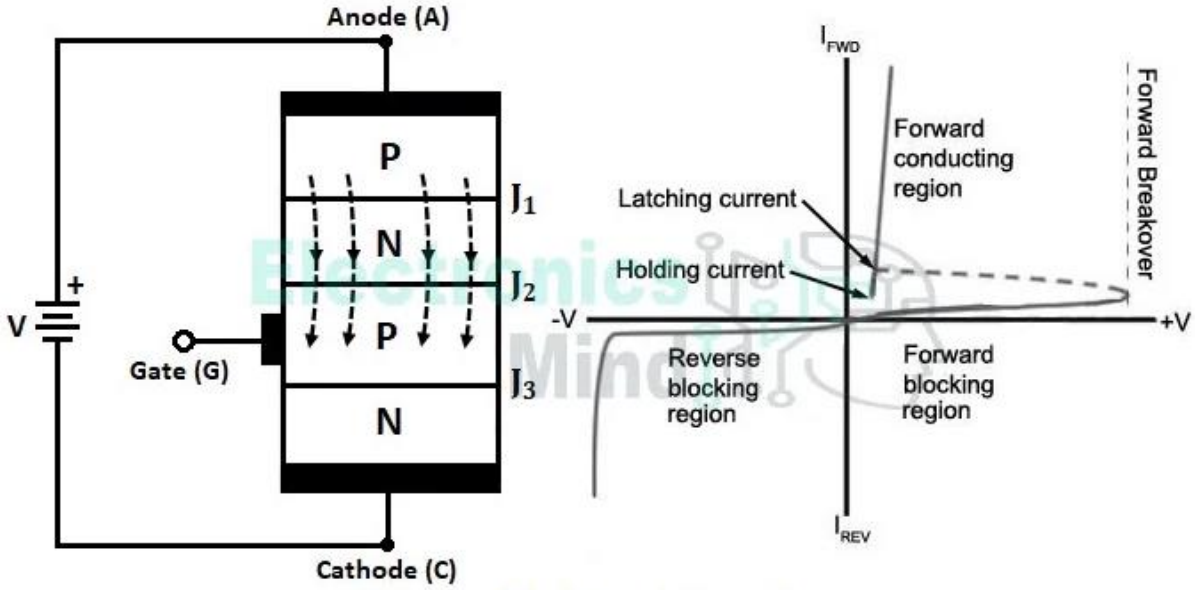


The various SCR triggering methods are

(a) Forward Voltage Triggering
(b) Thermal (or) Temperature Triggering
(c) Radiation or Light triggering
(d) dv/dt Triggering
(e) Gate Triggering

(a) Forward Voltage Triggering:-

- In this mode, an additional forward voltage is applied between anode and cathode.
- When the anode terminal is positive with respect to cathode(V_{AK}) , Junction J1 and J3 is forward biased and junction J2 is reverse biased.
- No current flows due to depletion region in J2 is reverse biased (except leakage current).
- As V_{AK} is further increased, at a voltage V_{BO} (Forward Break Over Voltage) the junction J2 undergoes avalanche breakdown and so a current flows and the device tends to turn ON(even when gate is open)



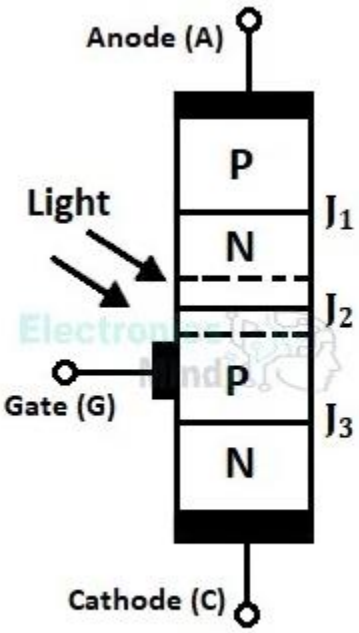
Forward Voltage Triggering

(b) Thermal (or) Temperature Triggering:-

- The width of depletion layer of SCR decreases with increase in junction temperature.
- Therefore in SCR when V_{AR} is very near its breakdown voltage, the device is triggered by increasing the junction temperature.
- By increasing the junction temperature the reverse biased junction collapses thus the device starts to conduct.

(c) Radiation Triggering (or) Light Triggering:-

- For light triggered SCRs a special terminal niche is made inside the inner P layer instead of gate terminal.
- When light is allowed to strike this terminal, free charge carriers are generated.
- When intensity of light becomes more than a normal value, the thyristor starts conducting.
- This type of SCRs are called as LASCR



Structure of LASCR

(d) dv/dt Triggering:-

- When the device is forward biased, J1 and J3 are forward biased, J2 is reverse biased.
- Junction J2 behaves as a capacitor, due to the charges existing across the junction.
- If voltage across the device is V, the charge by Q and capacitance by C then,

$i_c = dQ/dt$

$Q = CV$

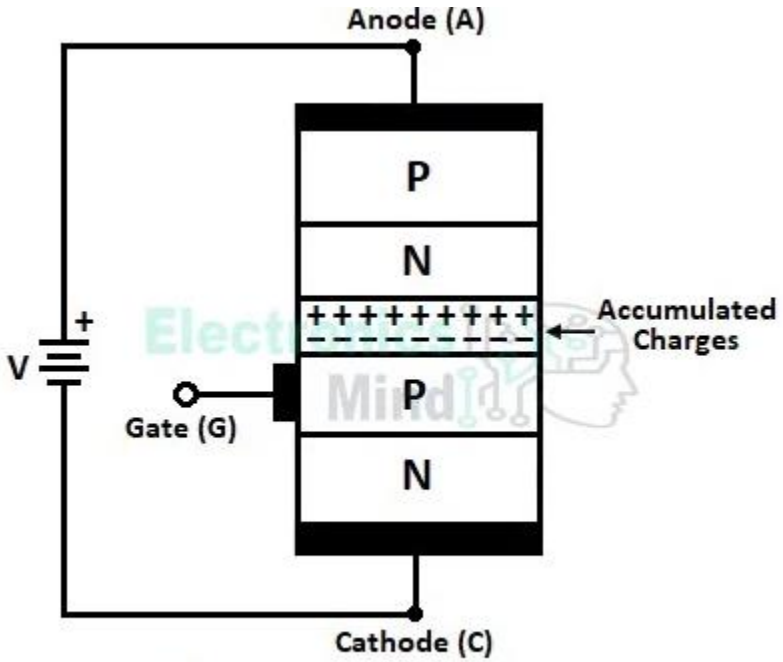
$i_c = d(CV) / dt$

$= C.\ dV/dt + V.\ dC/dt$

as dC/dt = 0

$i_c = C.dV/dt$

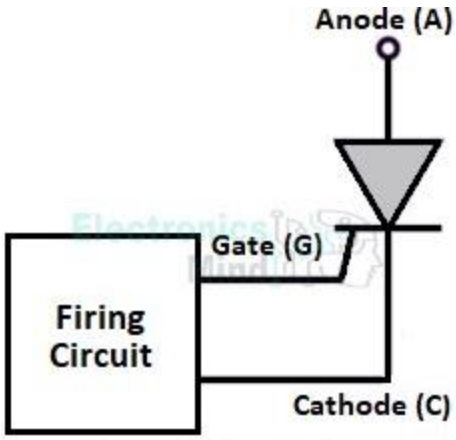
- Therefore when the rate of change of voltage across the device becomes large, the device may turn ON, even if the voltage across the device is small.



dV/dt Triggering

(e) Gate Triggering:-

- This is most widely used SCR triggering method.
- Applying a positive voltage between gate and cathode can Turn ON a forward biased thyristor.
- When a positive voltage is applied at the gate terminal, charge carriers are injected in the inner P-layer, thereby reducing the depletion layer thickness.
- As the applied voltage increases, the carrier injection increases, therefore the voltage at which forward break-over occurs decreases.
- Three types of signals are used for gate triggering.



Gate Triggering

Turning Off SCR – Commutation

Commutation:

The process of turning OFF SCR is defined as "Commutation".

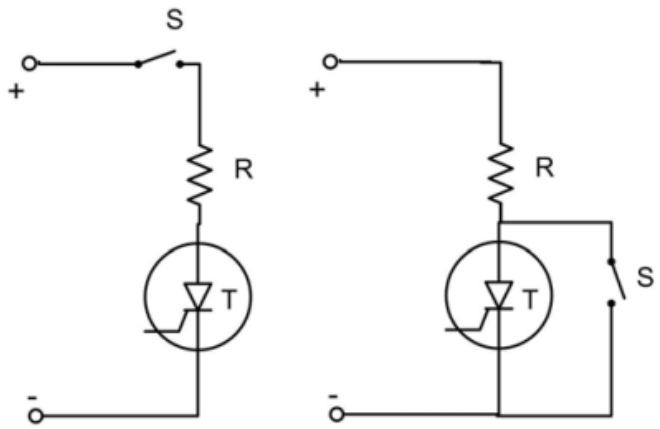
The process of SCR Turning-OFF is known as commutation. This means, some external techniques and circuit must be employed to turn off the SCR. This external circuit is known as Commutation Circuit. The Turn-Off process of an SCR is also known as SCR Commutation Method. An term Commutation means the transfer of currents from one path to another. So the Commutation Circuit does this job by reducing the Forward Current or Anode Current (Ia) below the Holding Current (I_H) level to Zero level or to make the Anode Negative with respect to the Cathode so as to Turn-Off the SCR (thyristor). The process of Turn OFF is known as Commutation.

- In all commutation techniques, a reverse voltage is applied across the thyristor during the turn OFF process.
- By turning OFF a thyristor we bring it from forward conducting to the forward blocking mode.
- The condition to be satisfied in order to turn OFF an SCR are:

    1. $I_A < I_H$ (Anode current must be less than holding current)
    2. A reverse voltage is applied to SCR for sufficient time enabling it to recover its blocking state.
- There are two methods by which a thyristor can be turned OFF.
    1. Natural Commutation
    2. Forced Commutation

Natural Commutation:-

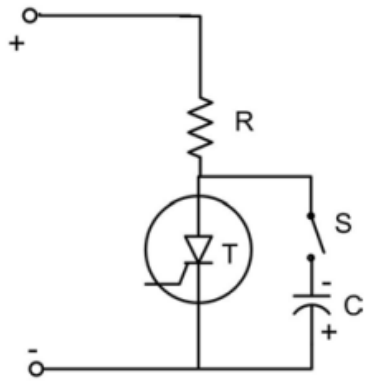
- In AC circuit, the current always passes through zero for every half cycle.
- As the current passes through natural zero, a reverse Voltage will simultaneously appear across the device.
- This will turn OFF the device immediately.
- This process is called as natural commutation, since no external circuit is required for this purpose.
  - In Dc circuit The thyrister current reduce to zero by opening the switch **S** to zero connected in series with thyrister as shown in fig (a)
  - Or by creating a bypass for the current by connecting switch in parallel across the thyrister as shown in fig (b) and the switch can be return to first state in both cases. A high dv/dt generated which may cause the thyrister to restart again.



(a) (b)

Forced Commutation:

- To turn OFF a thyristor, the forward anode current should be brought to zero for sufficient time to allow the removal of charged carriers.
- In case of DC circuits the forward current should be forced to zero by means of connected a switch and charge capacitor across thyrister forcing the current to zero and pass in opposite direction This process is called as forced commutation as shown in fig (c)



Fig(c)

PROTECTION of thyristor

SCR PROTECTION

For reliable and efficient operation SCR is design to operate within the specific PIV ratings. So they must be protected against abnormal operating conditions. So various protection Scheme available for satisfactory operation of SCR are

- Over Current Protection
- Over voltage Protection
- di/dt Protection
- dv/dt Protection
- Thermal Protection

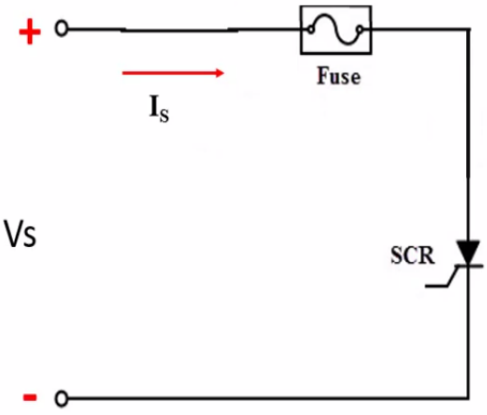
Activate Windows
Go to Settings to activate Wind

Over Current Protection

What is Overcurrent?

$I_S > I_{rated}$

In an SCR due to over-current, the junction temperature exceeds the rated value and the device gets damaged.



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Exit full screen (f)

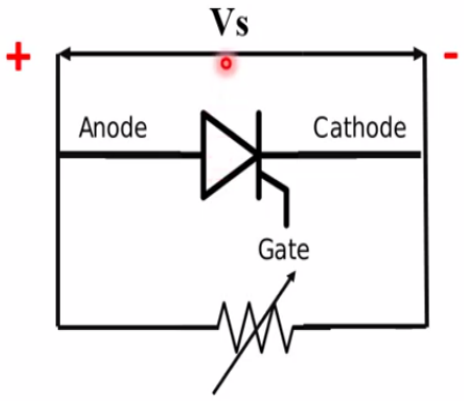
Over Voltage Protection

What is Overvoltage?

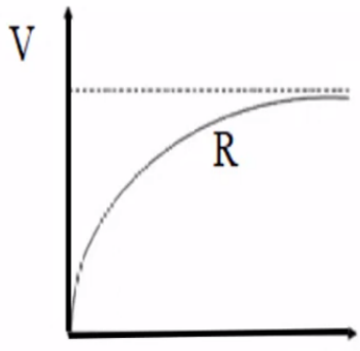
$V_S > V_{rated}$

Overvoltage may result in false turn ON of the device (or) damage the device

The effect of overvoltage is reduced by using Non-Linear resistors called Varistor.



Varistor

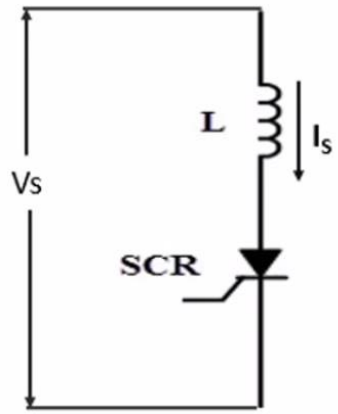


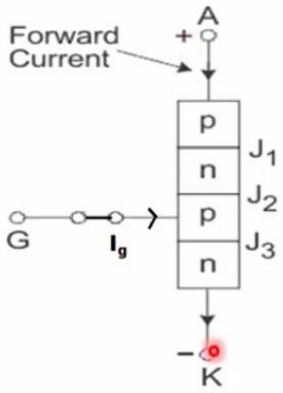
V-I Characteristic Varistor

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di / dt Protection

di/dt is the rate of change of current in a device.
The device protection is done by means of connecting an inductor in series with the thyristor.





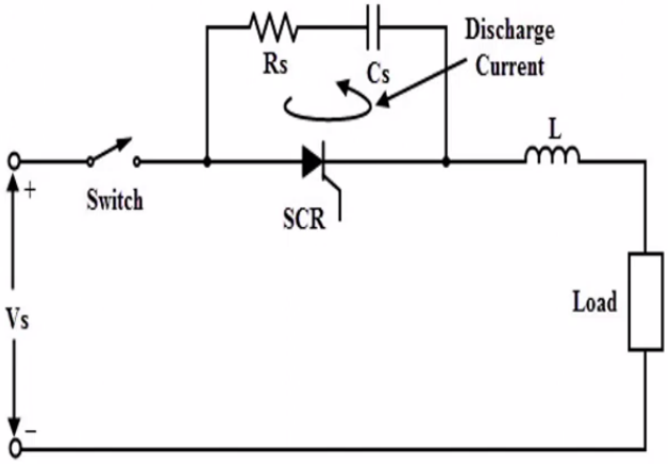
Forward Biased Condition

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SCR layer Structure

dv / dt Protection

dv/dt is the rate of charge of voltage across SCR. To protect the thyristor against false turn ON or against high dv/dt a "Snubber Circuit" is used. The snubber Circuit is a series combination of resistor 'R' and capacitor 'C'.



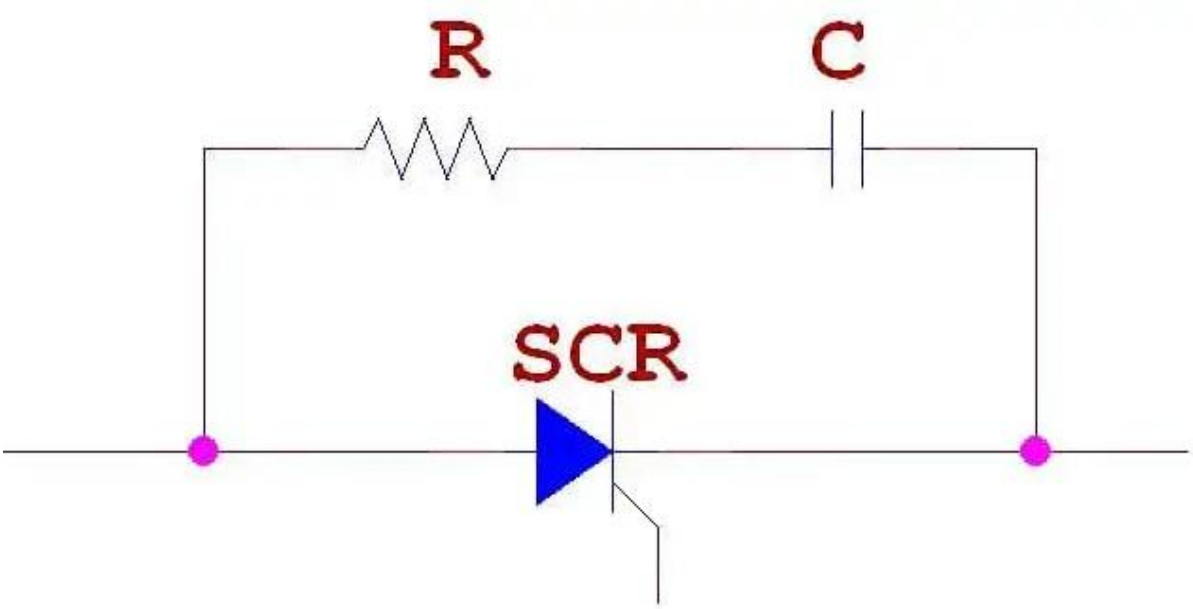
Charging current across capacitor

$$I = C\, dv/dt$$

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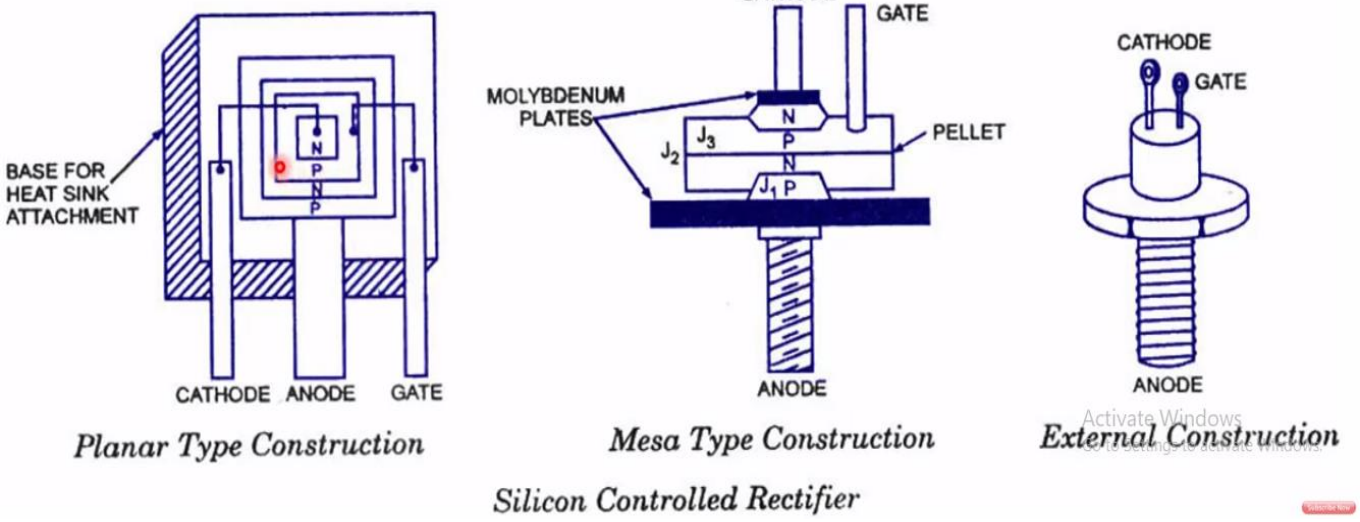
The Snubber circuit is one type of dv/dt protection circuit of the thyristor.

With the help of snubber circuit, the false turn-on of a thyristor due to large dv/dt can be prevented.



Thermal Protection

With the increase in the temperature of the junction, insulation may get failed and SCR may damage. So thermal protection achieve by mounting heat sink over SCR



Planar Type Construction *Mesa Type Construction* *External Construction*

Silicon Controlled Rectifier

Activate Windows
Go to Settings to activate Windows.