Unit → 2

1.) Triggering ...

SCR Turn ON Methods...

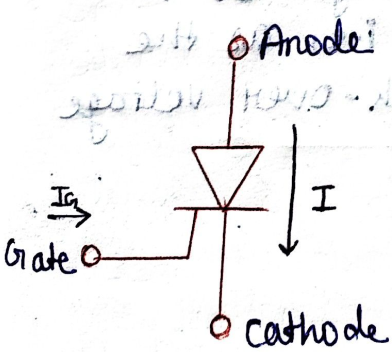
★ By raising temperature [Thermal triggering]

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

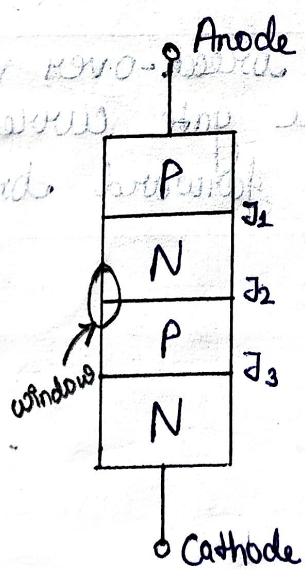
- As we increase current or temperature. then $\alpha_1 + \alpha_2 \rightarrow 1$.

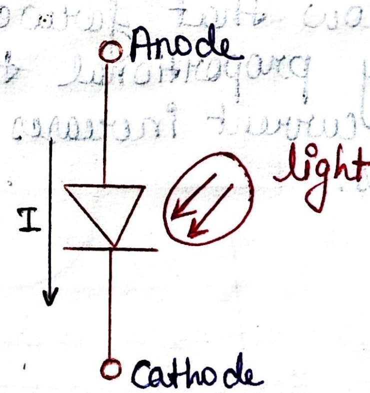
★ By light [Optical triggering]

- Light triggering is a specialized method used exclusively in light Activated silicon Controlled Rectifiers LASCR.
- When light is incident on the surface of the device, it generates photons.
- These photons create electron-hole pairs, which reduce the width of the depletion layer and facilitate the turning on of the LASCR.
- These thyristors are used in HDVC and FACT's controllers.



Normal SCR





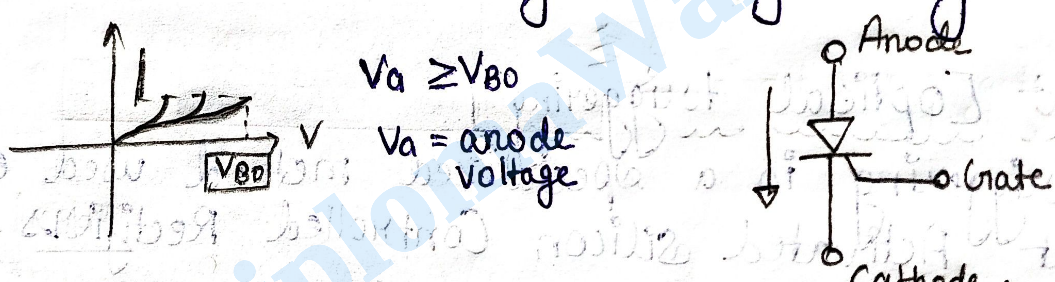
Light triggering

★ By high Voltage [Forward Voltage triggering]

- When anode is positive with respect to the Cathode, with gate circuit open, thyristor (SCR) is said to be forward biased.
  In this mode junction J_1 and J_3 are forward biased and junction J_2 is reverse biased.

- When $V_a \geq V_{BO}$, then the junction J_2 undergo avalace breakdown then huge I_a current flow and thyristor is turned ON.

- A huge I_a current flows the device may damage. And forward break over voltage V_{BO} and reverse break-over voltage V_{BR} are temperature dependent and $V_{BR} > V_{BO}$. Therefore, V_{BO} is taken as highest voltage rating.



★ By Gate Current [Gate triggering]

- When the anode is positive with respective cathode then the SCR is said to be forward, when a positive gate pulse is provide at junction J_2, it will inject some electrons and disturb the depletion layer, which result in increasing the reverse leakage current and hence the breakdown of J_2.

We know that forward break-over voltage V_{BO} is inversely proportional to the gate current i.e, as the gate current increases the forward break-over voltage decreases.

★ **By increasing dv/dt [dv/dt triggering]**

- When the SCR is in forward blocking mode, then the junction J_2 is reversed biased.
- The depletion layer in J_2 acts as a capacitor, it is formed due to polarization.

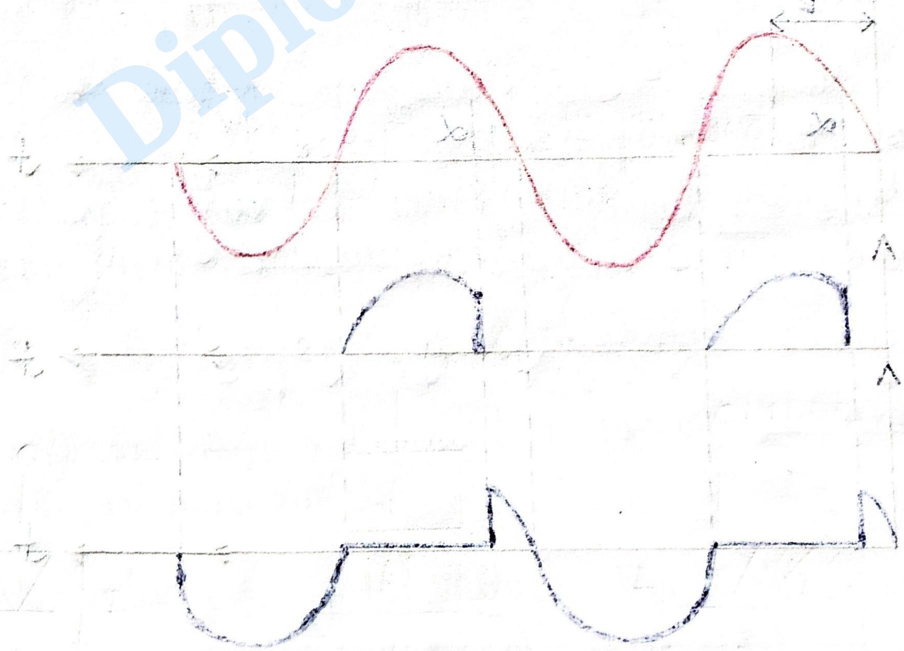
  We know for any capacitor current can be expressed as –

$$i_C = C\frac{dv}{dt}$$

- In the case of forward voltage V_a appears across reverse biased junction J_2, then charging current the junction is given by –

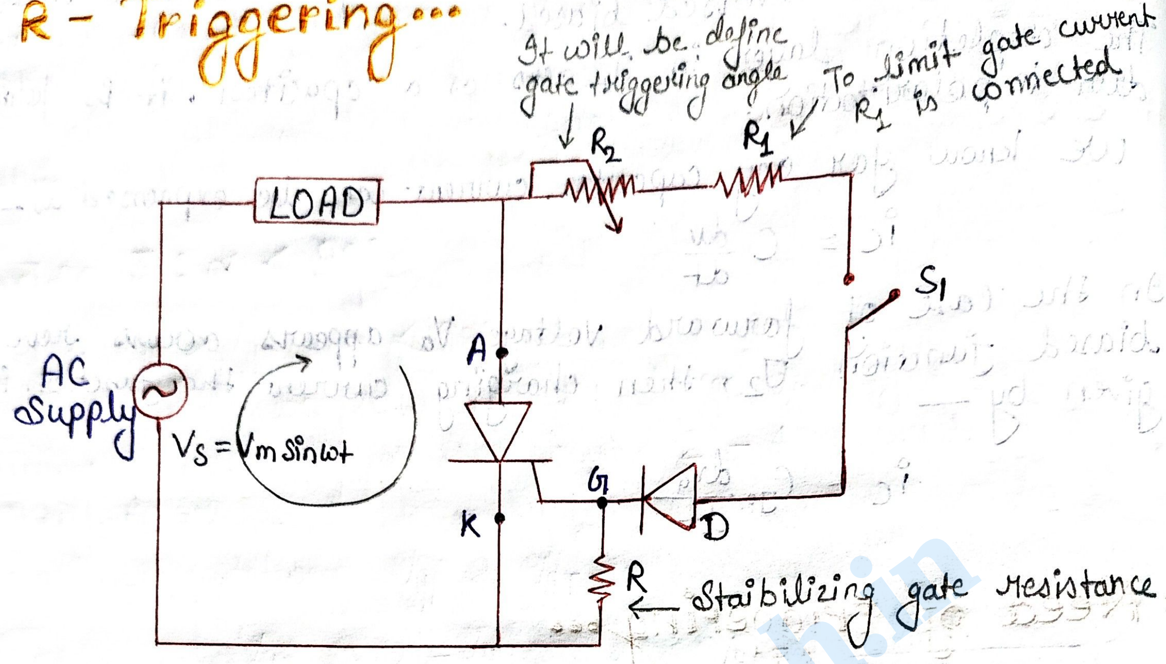
$$i_C = C_{J_0}\frac{dv_a}{dt}$$

Need of triggering...

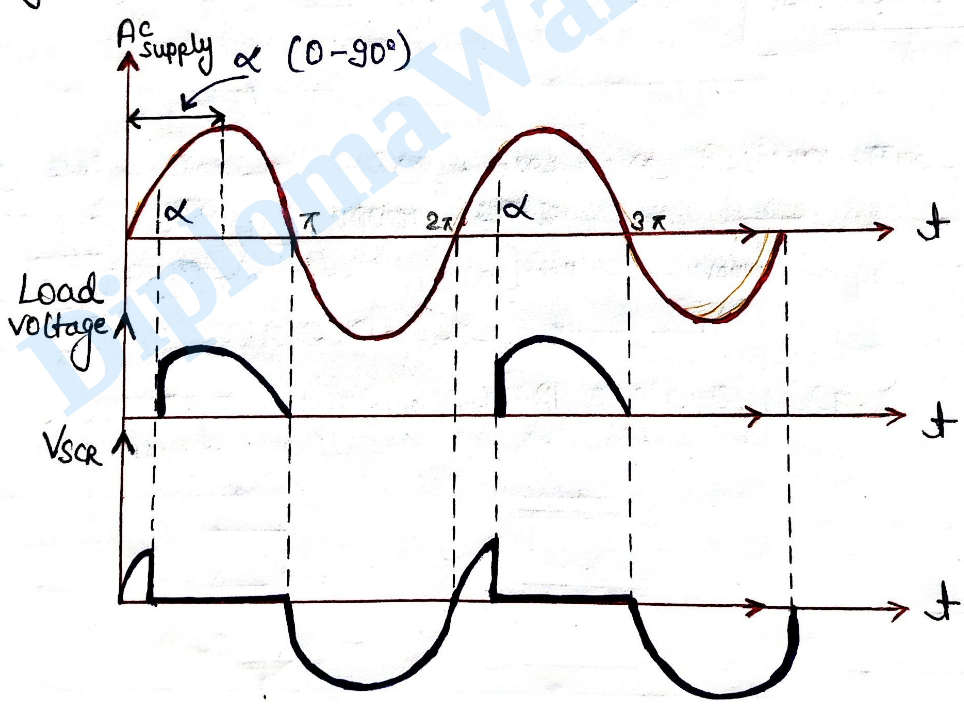


Triggering circuits :-

R - Triggering...



Waveform



→ If R is more, α is less.

→ If R is less, α is more.

→ Range of α (firing angle). is in between 0 to 90°.

- Simplest triggering circuit.
- Limited triggering angle range (0° to 90°).
- In the above fig. R_1 is the current limiting resistor, R_2 is the variable resistor which controls the firing angle and R is the stabilizing resistor.
- If $R_2 = 0$, then the current is limited by R_1.
- This current should not > max. permissible gate current I_{gm}. Therefore, R_1 can be found as follows:

$$I_{gm} \leq \frac{V_m}{R_1} \Rightarrow R_1 \geq \frac{V_m}{I_{gm}}$$

- R is chosen s. t. max. voltage across it doesn't exceed maximum forward gate voltage V_{gm}.

Therefore,

$$\frac{V_m}{R+R_1} R \leq V_{gm} \Rightarrow R \leq \frac{V_{gm} R_1}{V_m - V_{gm}}, \quad (R_2 = 0)$$

- Gate trigger circuit draws a small current due to large values of R_1 & R_2.
- Gate voltage V_g is a half wave pulse because diode D allows the flow of current only in +ve half cycle. Its amplitude is governed by R_2.

Case 1 : R_2 is large, No Triggering

- When R_2 is large, current i is small and voltage $V_g = iR$ is also small.
- If peak value of gate voltage $V_{gp} < V_{GT}$, SCR will not turn ON and accordingly there will be no O/P voltage or current and the supply voltage will appear on the SCR.

Case 2 : $\alpha = 90°$

- When R_2 is decreased s.t. $V_{gp} = V_{GT}$, $\alpha = 90°$ is obtained which can't increase beyond this value.
- This is because the thyristor latches into conduction as soon as V_{gp} becomes equal to V_{GT} for the first time.

Case 3 : $\alpha < 90°$

- When $V_{gp} > V_{gT}$, $\alpha < 90°$
- Also α can't be zero however large V_g may be.
- Minimum value of α is about $2° - 4°$ (which is obtained when $R_2 = 0$).
- Relationship between V_{gp} & V_{gT} is

$$V_{gp} \sin\alpha = V_{GT}$$

$$\text{or}, \quad \alpha = \sin^{-1}\left(\frac{V_{GT}}{V_{gp}}\right)$$

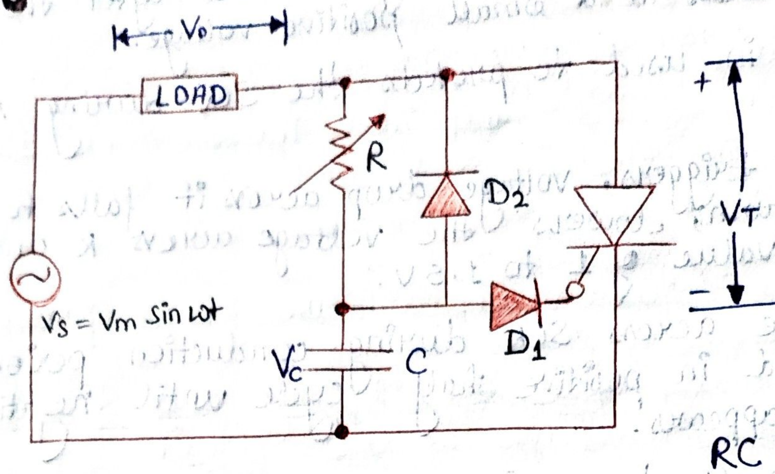
$$V_{gp} = \left[\frac{V_m R}{R_1 + R_2 + R}\right]$$

$$\alpha = \sin^{-1}\left[\frac{V_{GT} \cdot (R_1 + R_2 + R)}{V_m R}\right]$$

RC - Triggering...

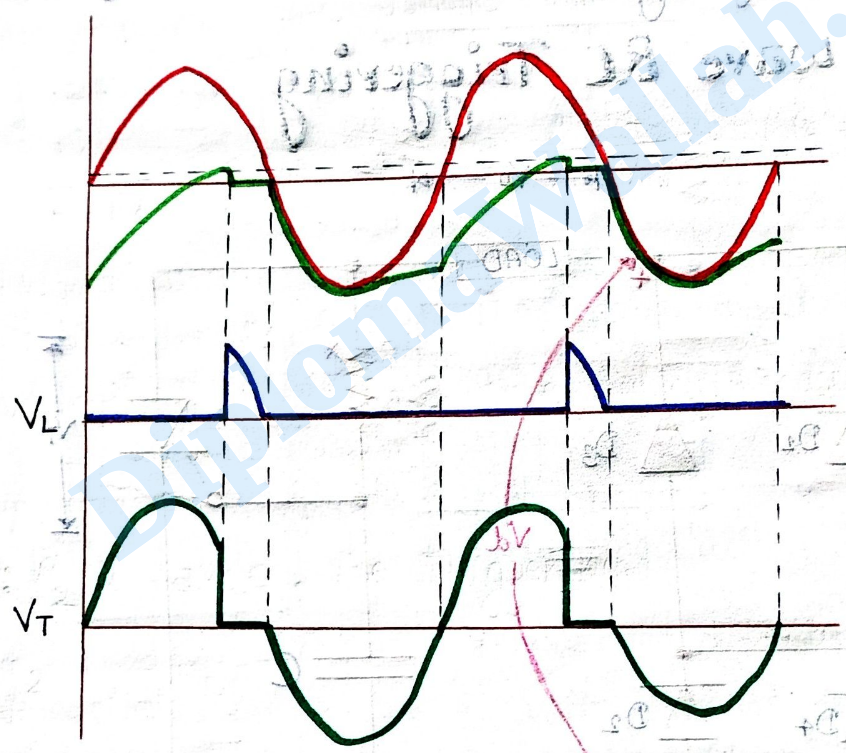
- In RC triggering of SCR, we take Resistor and capacitor elements to trigger SCR.
- Value of Resistor and Capacitor is very important to define firing angle of SCR.
- RC time constant defines firing angle of SCR.

⋆ Half Wave RC Triggering



$$RC \geq \frac{1.3T}{2}$$

Waveform

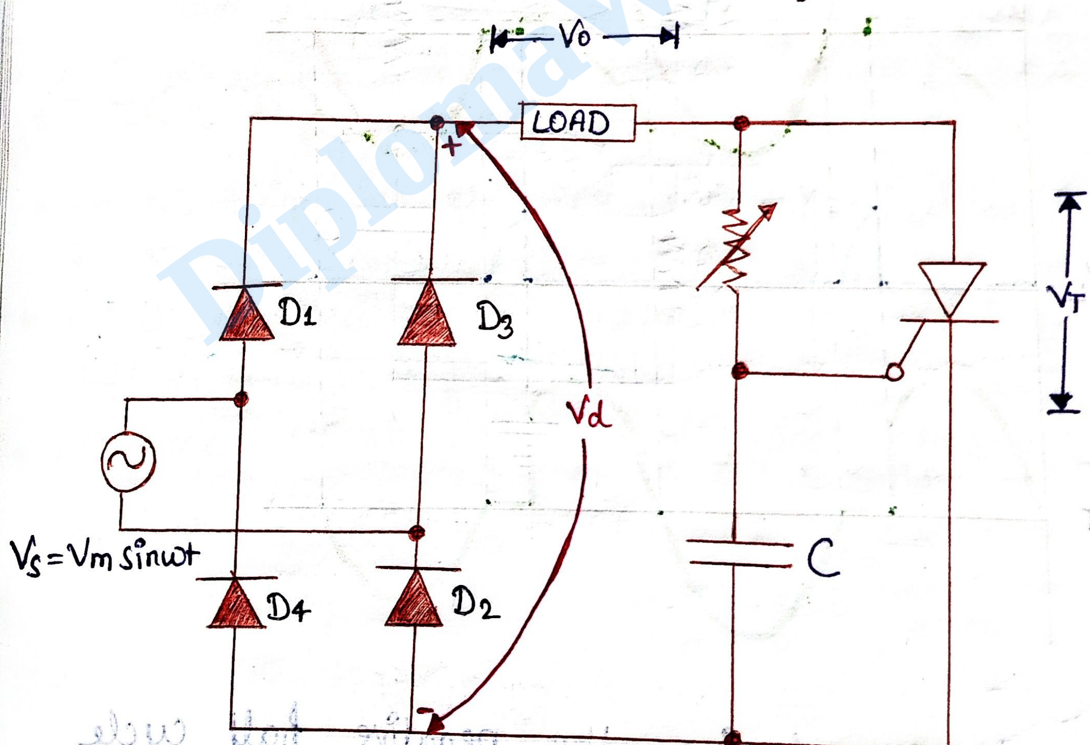


- Capacitor charges during the negative half cycle through D_2.
- Now, the SCR anode voltage passes through zero and and becomes positive, C begins to charge through variable resistance R from the initial voltage − oa.

- When capacitor charges to positive voltage equal to gate trigger voltage V_{g1}, SCR is fired and after this, capacitor holds to a small positive voltage.
- Diode D_1 is used to protects the SCR during negative half cycle.

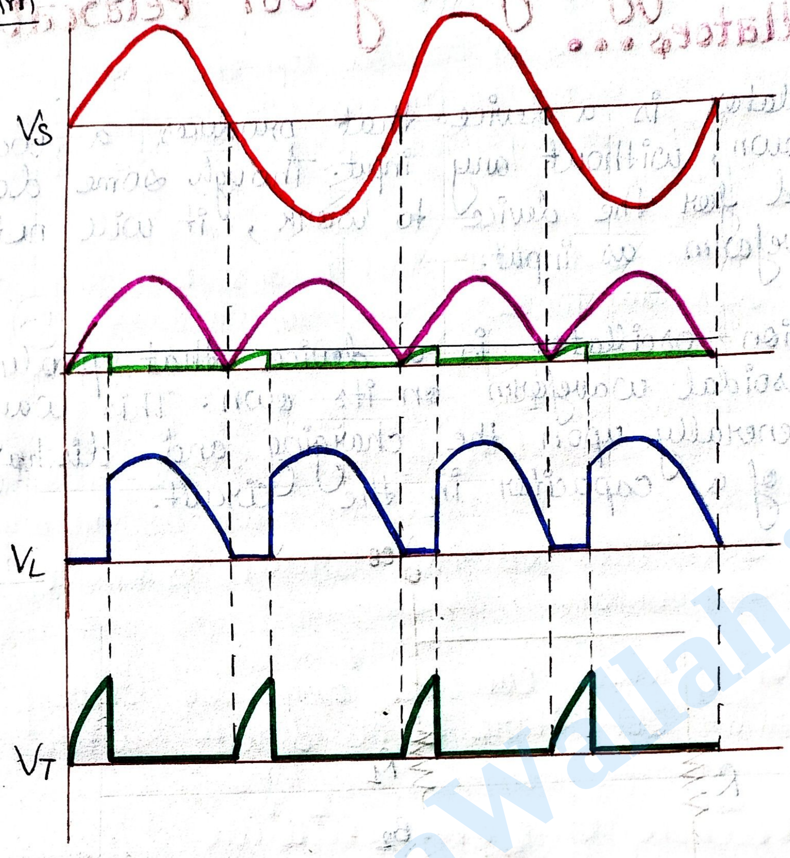
* When SCR triggers, voltage drop across it falls to 1 to 1.5V. This, in turn, lowers the voltage across R and C to this low value of 1 to 1.5 V.
* Low voltage across SCR during conduction period keeps C discharged in positive half cycle until negative cycle across C appears.
* This charges C to maximum negative voltage $-V_m$ as shown in Fig. by dotted line.

★ Full wave RC Triggering



$$RC \geq \frac{50T}{2} \qquad R \leq \frac{V_s - V_{gmin}}{I_{gmin}}$$

Waveform

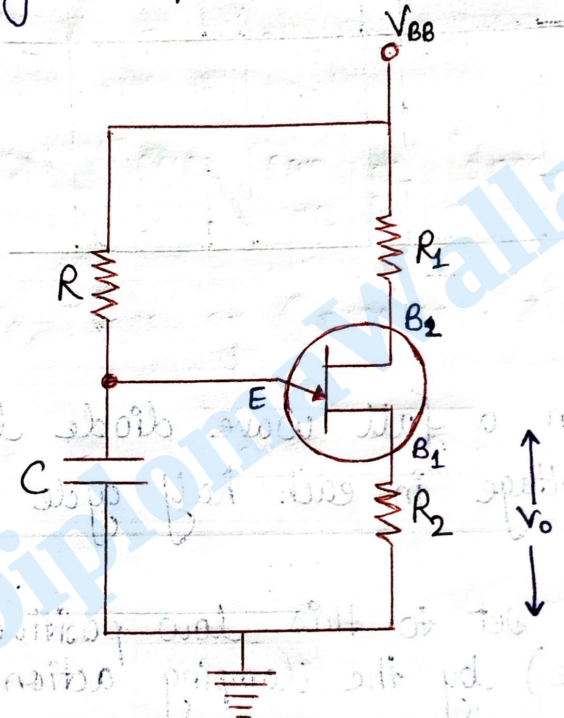


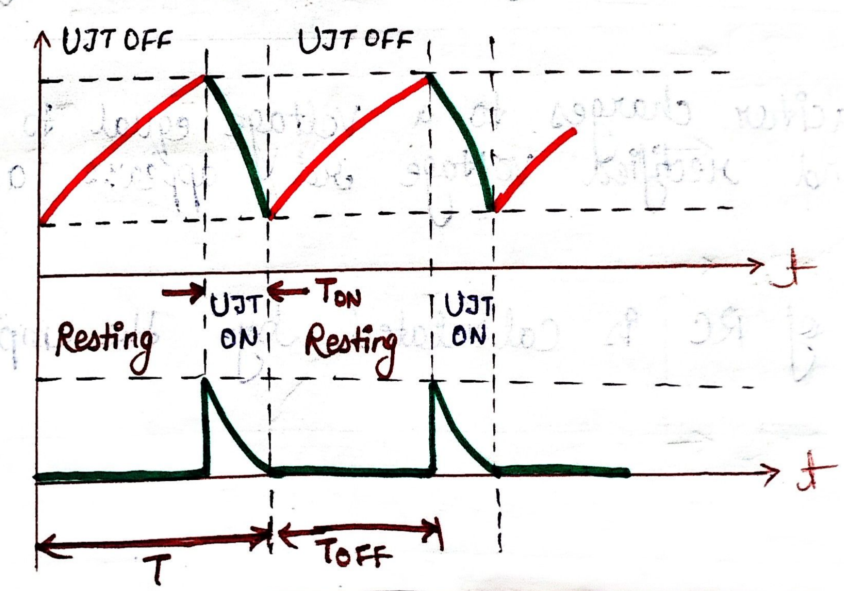
- Diodes D1 – D4 form a full wave diode bridge.
- Initial Capacitor voltage in each half cycle is almost zero.
- The Capacitor C is set to this low positive voltage (upper plate positive) by the clamping action of SCR gate.
- When Capacitor charges to a voltage equal to Vgt, SCR triggers and rectified voltage rd appears across load as Vo.
- The value of RC is calculated by the empirical relation.

2.) Pulse triggering using UJT relaxation Oscillators...

- An oscillator is a device that produces a waveform by its own, without any input. Though some dc voltage is applied for the device to work, it will not produce any waveform as input.

- A relaxation oscillator is a device that produces a non-sinusoidal waveform on its own. This waveform depends generally upon the charging and discharging time constants of a capacitor in the circuit.





★ Construction...

- The emitter of UJT is connected with a resistor and capacitor as shown.
- The RC time constant determines the timings of the output waveform of the relaxation oscillator. Both the bases are connected with a resistor each. The dc voltage supply V_{BB} is given.

★ Working...

- Initially, the voltage across the capacitor is zero.

$$V_C = 0$$

- The UJT is in OFF condition. The resistor R provides a path for the capacitor C to charge through the voltage applied.
- The capacitor charges according to the voltage

$$V = V_0 (1 - e^{-t/RC})$$

The capacitor usually starts charging and continues to charge until the maximum voltage V_{BB}.

- But in this circuit, when the voltage across capacitor reaches a value, which enables the UJT to turn ON (the peak voltage) then the capacitor stops to charge and ~~starts~~ discharging through UJT.
- Now, this discharging continues until the minimum voltage which turns the UJT OFF (the valley voltage). This process continues and the voltage across the capacitor.
- So, the charge and discharge of capacitor produces the sweep waveform as shown above. The charging time produces increasing sweep and the discharging time produces decreasing sweep.
- The repetition of this cycle, forms a continuous sweep output waveform. As the output is ~~said to be~~ a non-sinusoidal waveform, this circuit is said to be working as a relaxation oscillator.

3.) Commutation...

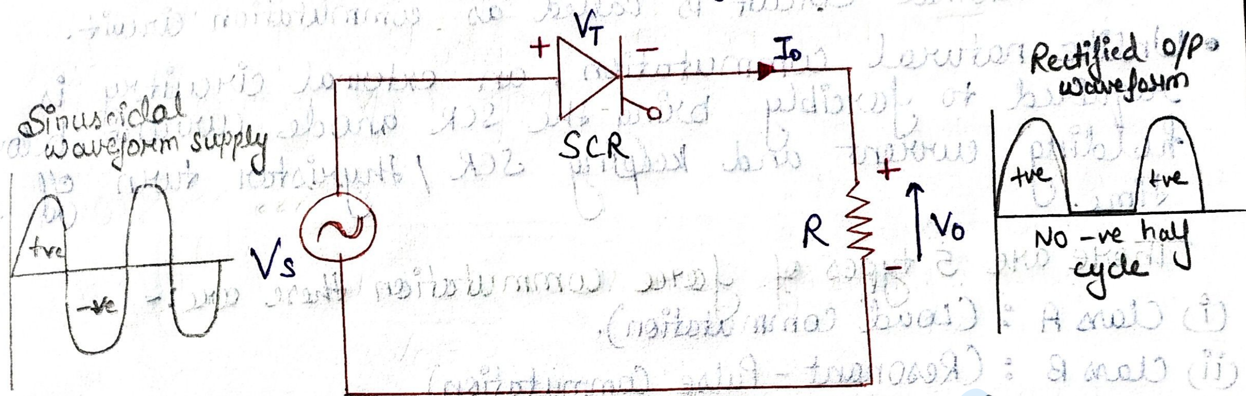
- Commutation of SCR is defined as the process of turning off an SCR / thyristor. It is the process by which an SCR or thyristor is bought to OFF state from ON state.
- Turn off of a SCR/thyristor means bringing it to forward blocking mode from forward conduction mode.
- We also know that, once an SCR goes in forward conduction mode, gate loses its control. This means, some external techniques / circuit must be employed to turn off SCR. This external circuit is known as commutation circuit.
- Turning ON process can be done by Gate pulse but for Turning OFF, there is no direct switch.

★ Classification of Commutation

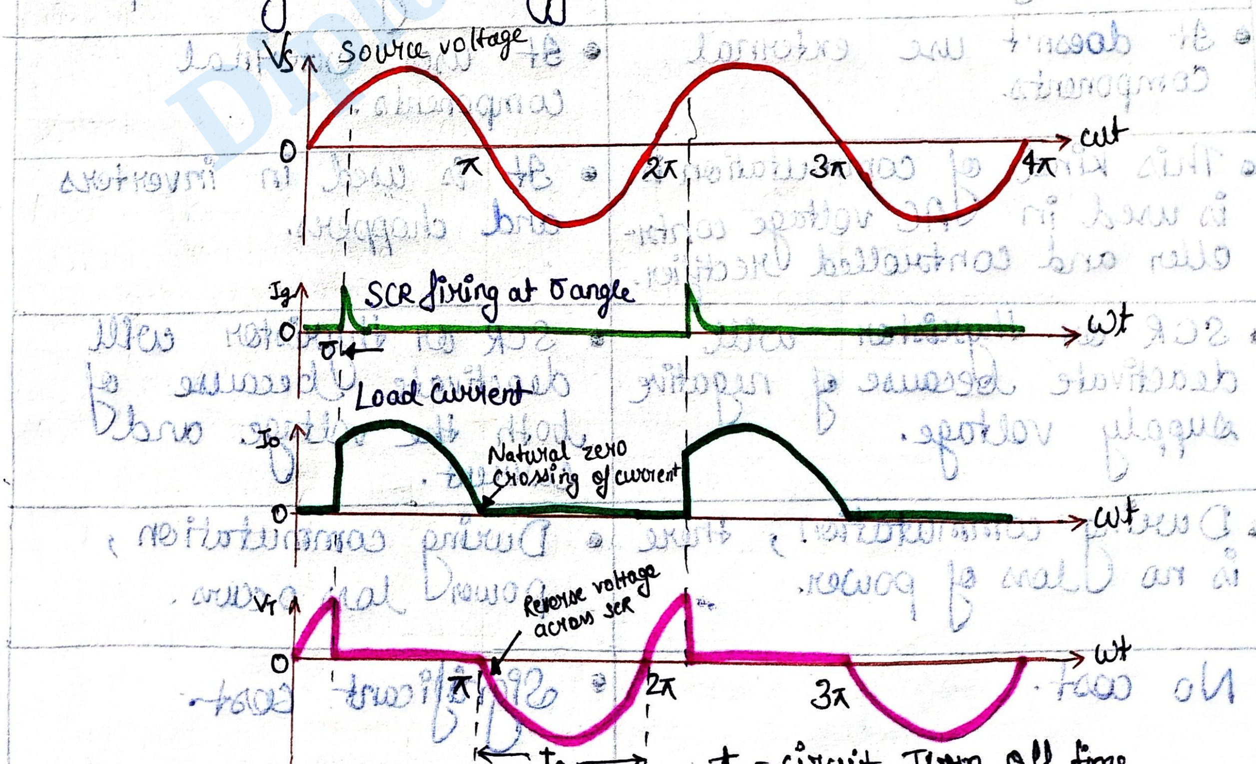
- Commutation
  - Natural Commutation or Line Commutation [AC]
    - Class F Commutation
  - Forced Commutation [DC supply]
    - Class A (Load Commutation)
    - Class B (Resonant Pulse Commutation)
    - Class C (Impulse / Complimentary commutation)
    - Class D (Voltage Commutation) / Auxiliary commutation

Natural Commutation :-

- Natural commutation of SCR is the process of turning off an SCR without using additional commutation circuitry.
- This commutation technique only occurs in AC circuit.



- When SCR is conducting, the current will pass through zero after every positive half cycle.
- After that, the AC source then applies a reverse voltage across the terminals of SCR till the begining of second cycle.
- If the time of application of reverse voltage applied by the AC source is more than the SCR turn-off time, then SCR will get turned off.



Forced Commutation...

- When the SCR is operated on the DC supply, it is not turned off naturally. The SCR is turned off by some external circuit is called as forced commutation.
- This external circuit is called as commutation circuit.
- Unlike natural commutation, an external circuitry is required to forcibly bring the SCR anode current below holding current and keeping SCR / thyristor turn off time.

There are 5 types of force commutation these are:-

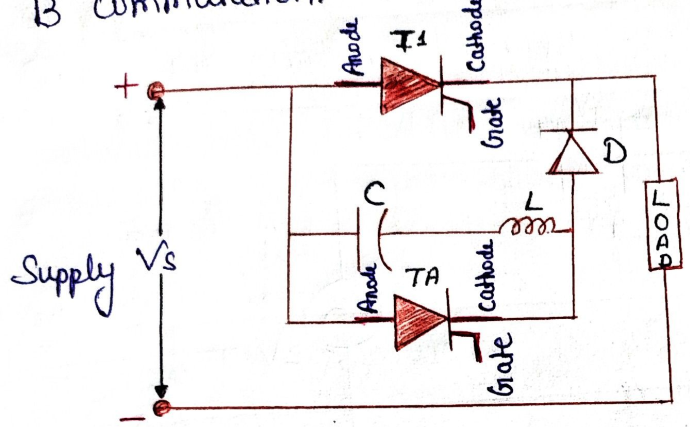
(i) Class A : (Load commutation).
(ii) Class B : (Resonant - Pulse Commutation).
(iii) Class C : (Complementary commution).
(iv) Class D : (~~Impulse~~ Voltage Commutation) / Auxiliary commutation.
(v) Class E : (External Pulse Commutation).

★ Difference between Natural and Forced Commutation:-

Natural Commutation	Forced Commutation
• Natural commutation uses AC voltage at the input.	• Forced commutation uses DC voltage at the input.
• It doesn't use external components.	• It uses external components.
• This kind of commutation is is used in AC voltage controller and controlled rectifier.	• It is used in inverters and choppers.
• SCR or thyristor will deactivate because of negative supply voltage.	• SCR or thyristor will deactivate because of both the voltage and current.
• During commutation, there is no loss of power.	• During commutation, power loss occurs.
• No cost.	• Significant cost.

Resonant Commutation... (Class B).

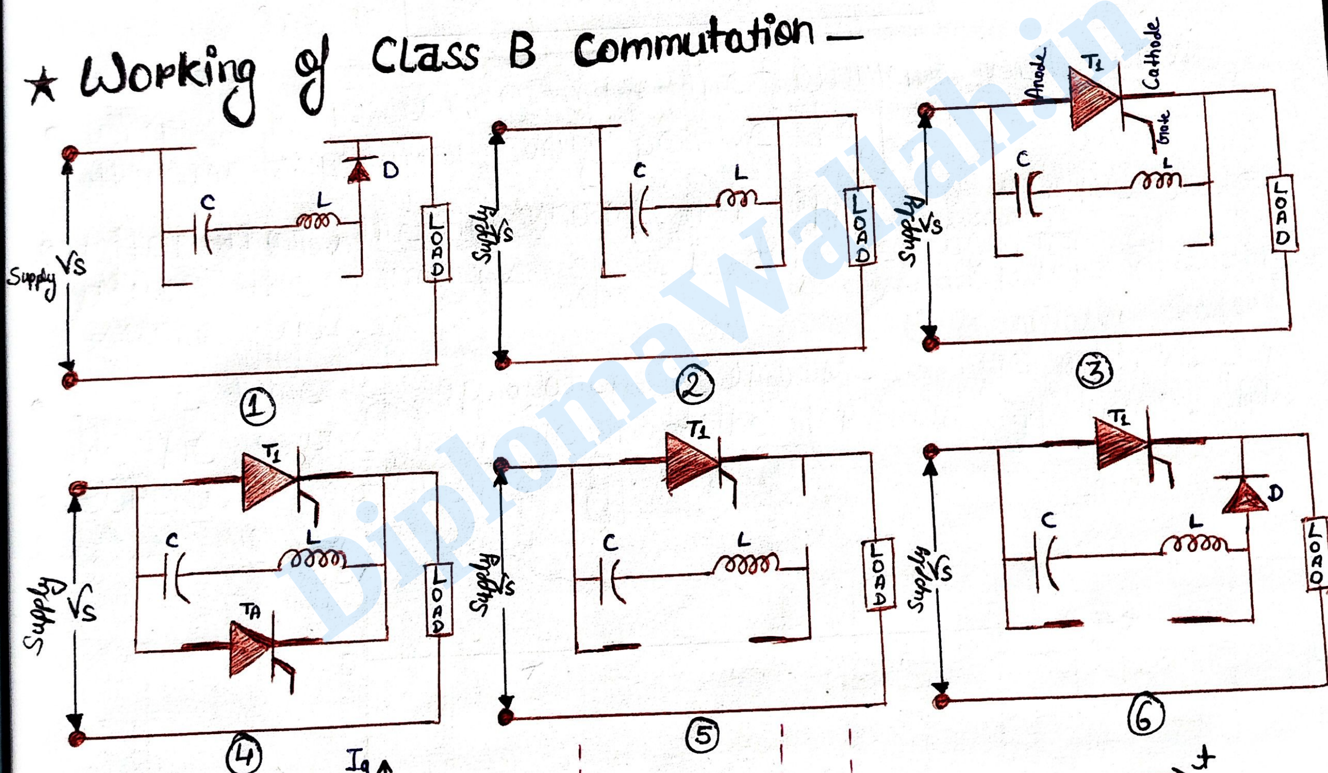
- It is also reffered as current commutation or class B commutation.



Assumption

- Load current is constant.
- LC circuit is resonating in nature.
- C is initially charged by Vs.

★ Working of Class B Commutation –



Waveform