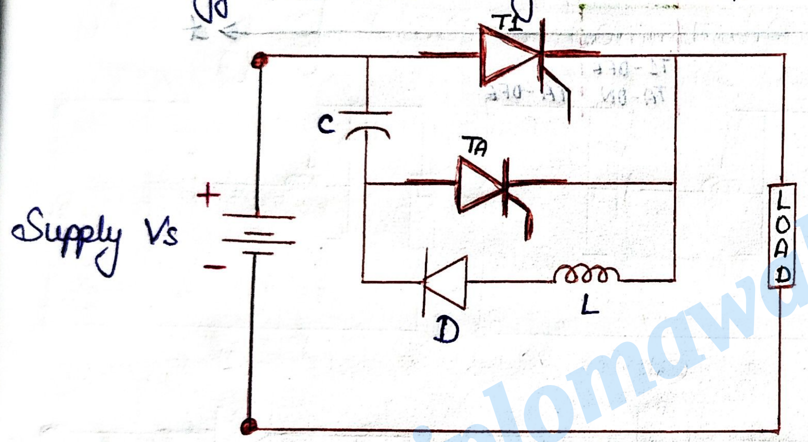
Unit → 3

1.) Auxiliary Commutation... (Class D)

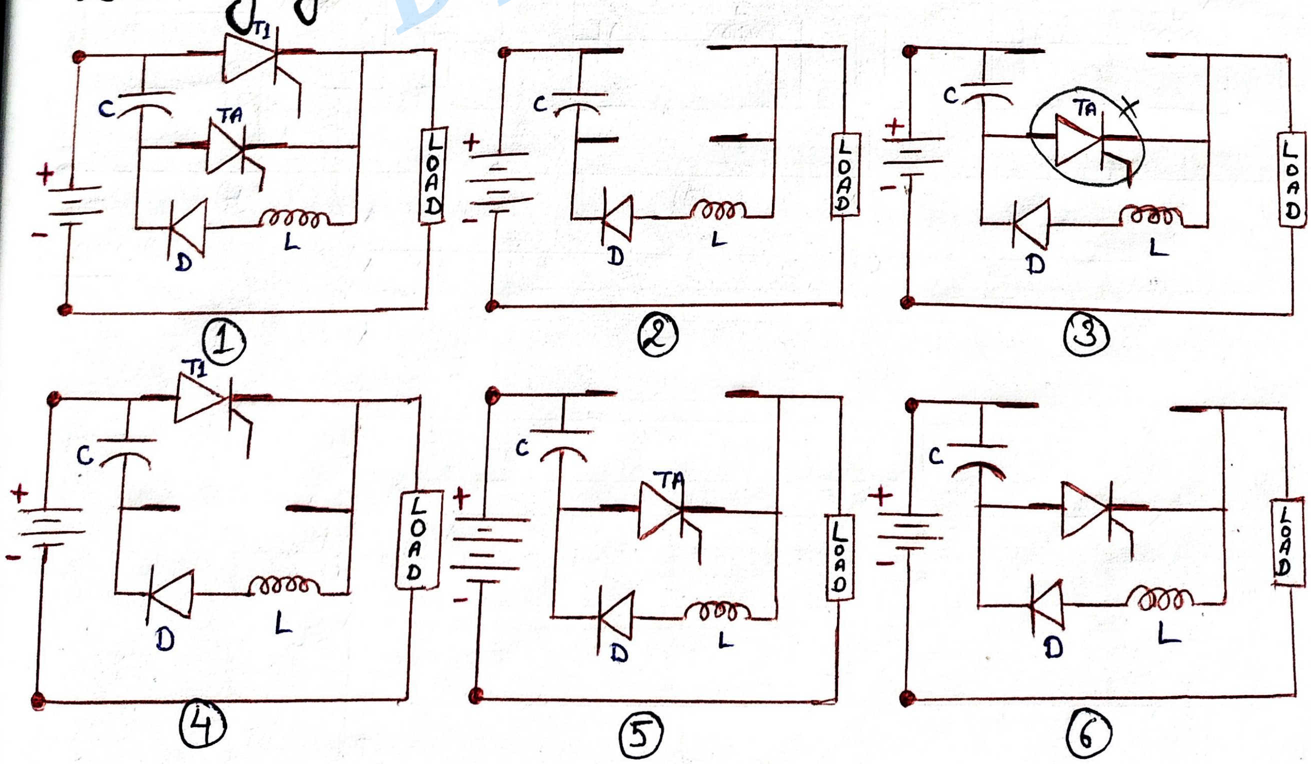
- It is also referred as Voltage commutation or Class D commutation. / Parallel Capacitor Commutation.
- In this method of commutation, a reverse voltage is suddenly applied across the thyristor, to turn it off. So, it is also known as voltage commutator.
- This type of commutation is also known as auxiliary commutation, as an auxiliary thyristor T_A is used to turn off the main thyristor T_M.



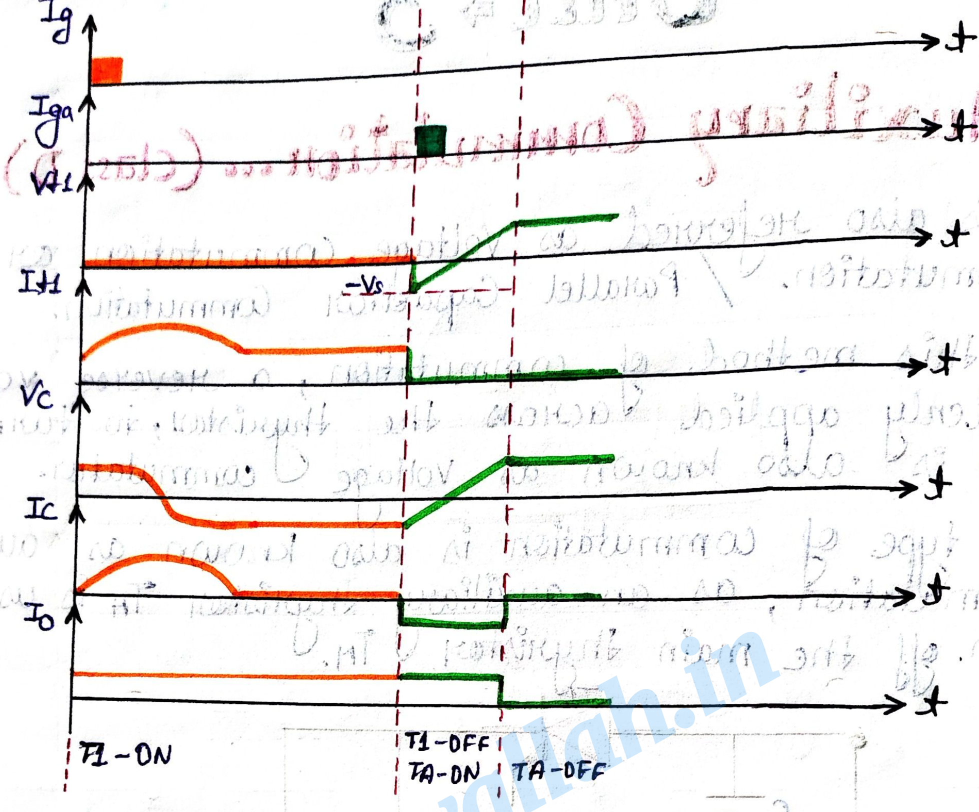
Assumption

- Load current is constant.
- C is initially charged by Vs.

★ Working of Class D Commutation...

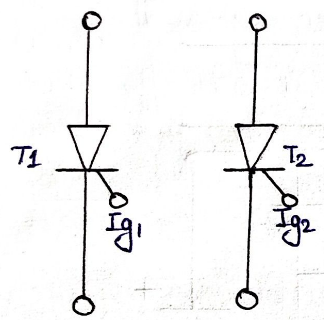


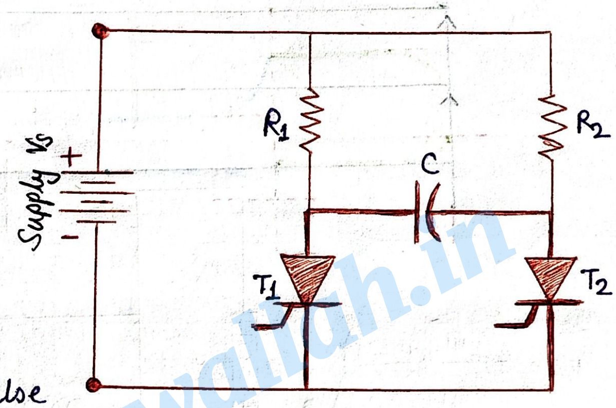
Waveform



Complementry Commutation... (class C).

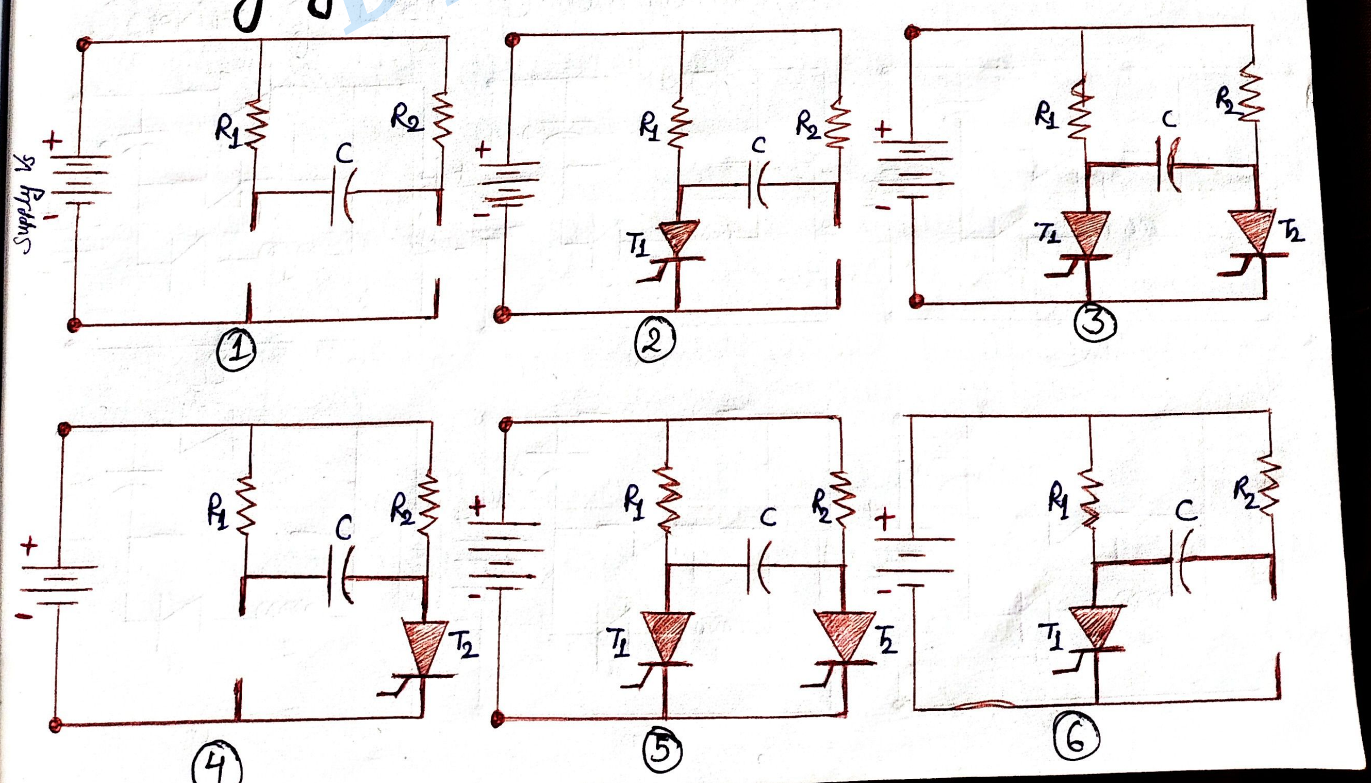
- It is also referred as Impulse commutation or Class C commutation.
- In this technique two thyristors are used for carrying the load current alternately.
- One thyristor is turned-off by turning on the other thyristor. The load current also ~~refers~~ transfers from the outgoing thyristor to incoming thyristor.



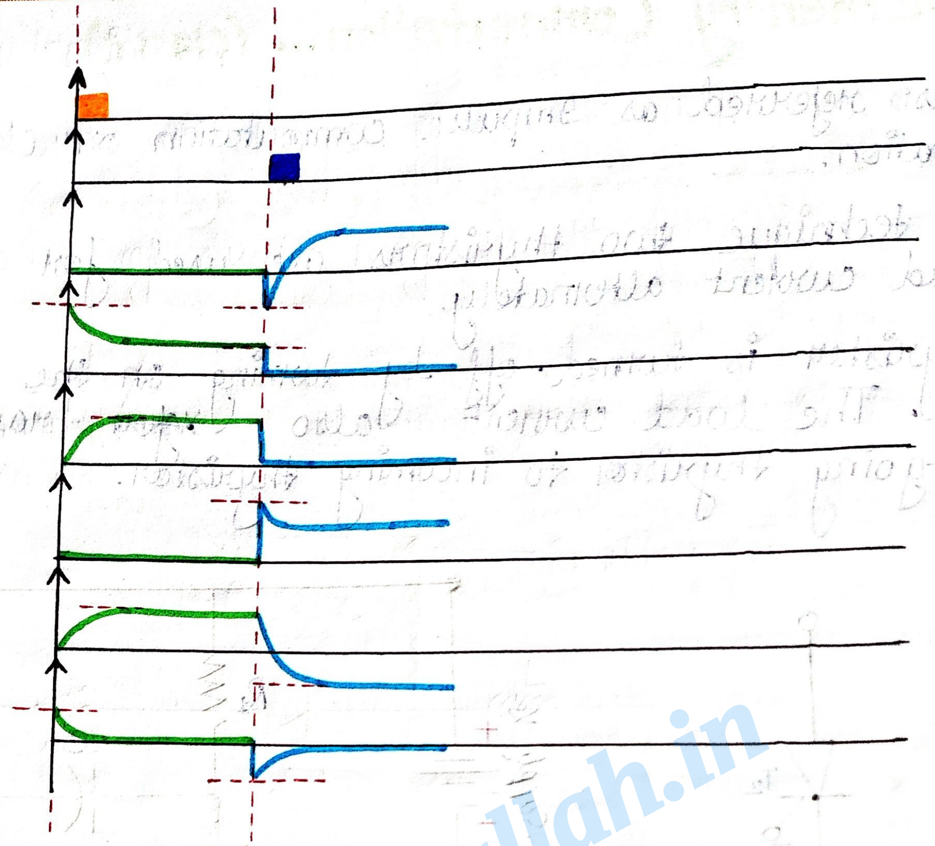


To turn OFF SCR T1. gate pulse is given to SCR T2.
To turn OFF SCR T2. gate pulse is given to SCR T1.

★ Working of Class C Commutation



Waveform



2) Protection of SCR...

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

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

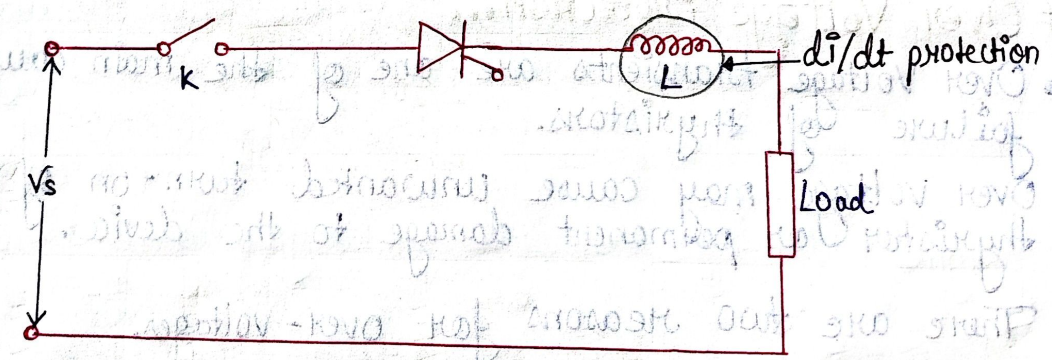
(i) $\frac{di}{dt}$ protection

(ii) $\frac{dv}{dt}$ protection

(iii) Over voltage protection

$\frac{di}{dt}$ protection...

- di/dt is rate of change of current in device.
- When SCR is in forward bias, and it is ON by gate signal then, there will be flow of anode current.
- The anode current requires some time to spread inside device.
- di/dt > spread velocity of charge. then it creates hot spot and that may damage SCR.
- So, to maintain di/dt through SCR, we connect inductor in series to the SCR.



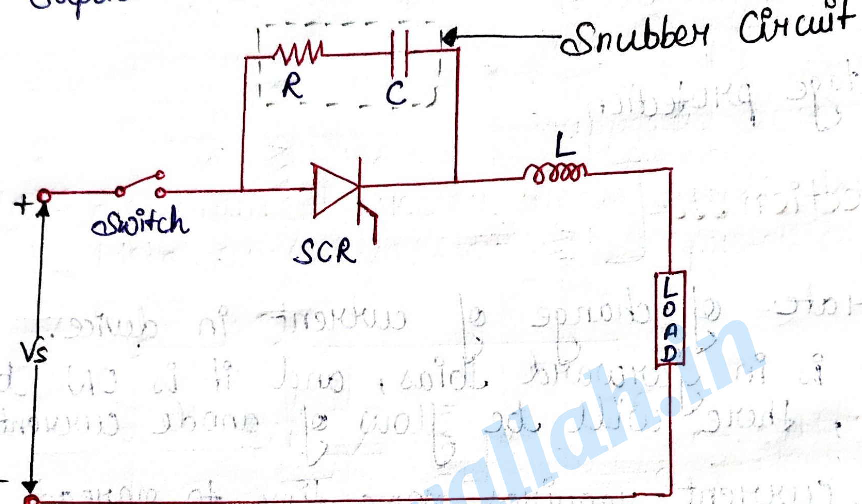
- Voltage across inductor can be calculated by

$$V_s = L\, di/dt \Rightarrow L = V_s / di/dt$$

$$\boxed{L > V_s / di/dt}$$

$\frac{dv}{dt}$ protection...

- dv/dt is rate of change of voltage with respect to time.
- Higher value of dv/dt may result into false turn ON of SCR.
- To provide dv/dt protection we connect Snubber Circuit. The snubber Circuit is a series combination of Resistor 'R' and Capacitor 'C'.



- Capacitor is connected to bypass high dv/dt through SCR.
- Resistor is connected to decrease discharge current of Capacitor through SCR.
- This R-C series across SCR is called Snubber circuit.

Over Voltage Protection...

- 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 cause for over voltages.

(ii) External causes of over voltages.

(i) Internal causes of over-voltages.

Over voltage generated during commutation of a thyristor.

⇓

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

(ii) External causes of over-voltages.

- Due to interruption of current in an inductive circuit.
- Due to lightning strike on feeder lines.
- Due to energizing or de-energizing of primary of transformer connected in the circuit.

★ Over voltage protection of thyristor is achived by use of:-

(a) Voltage Snubber circuit or RC circuits.

(b) Voltage Clamping device or Non-Linear resistors.

(a) Use of Snubber circuit or RC circuit...

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

(b) Use of Voltage-Clamping device or Non-linear resistor...

- 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.

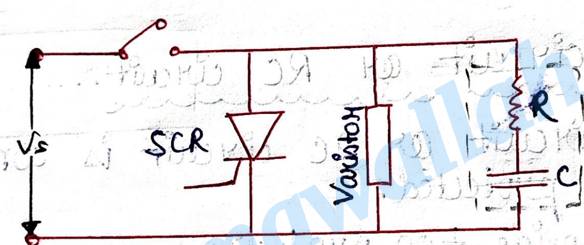
Under normal condition

↳ voltage is within limits ⇒ so, resistance is high
⇓
so, it only allow very small current.

When over-voltage occurs

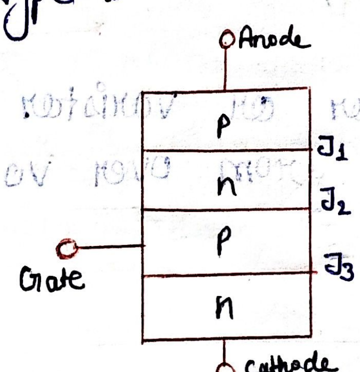
↳ when surge voltage appears ⇒ the device resistance decreases
⇓
it almost create a short-circuit path across SCR. The only a small voltage appears across SCR.

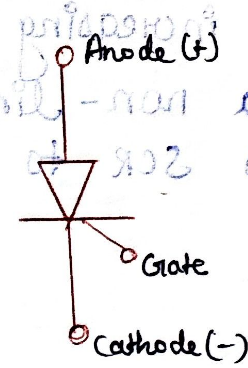
Example :- Selenium thyrecter diodes, Metal oxides varistors → used for over-voltage protection of SCR.



3.) Controlled rectifiers ... (SCR) Thyristor

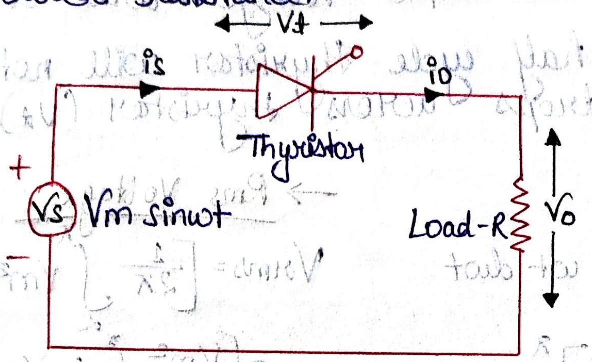
- The word thyristor is derived by a combination of the THYRathon and tranSTOR, which means that thyristor is a solid state device like transistor and has a characteristics similar to that of the thyratron tube.
- SCR is one of the semi-conductor device in thyristor family.
- Silicon Controlled Rectifier is four layers of alternate p-type and n-type semiconductors forming three junctions J_1, J_2 and J_3.

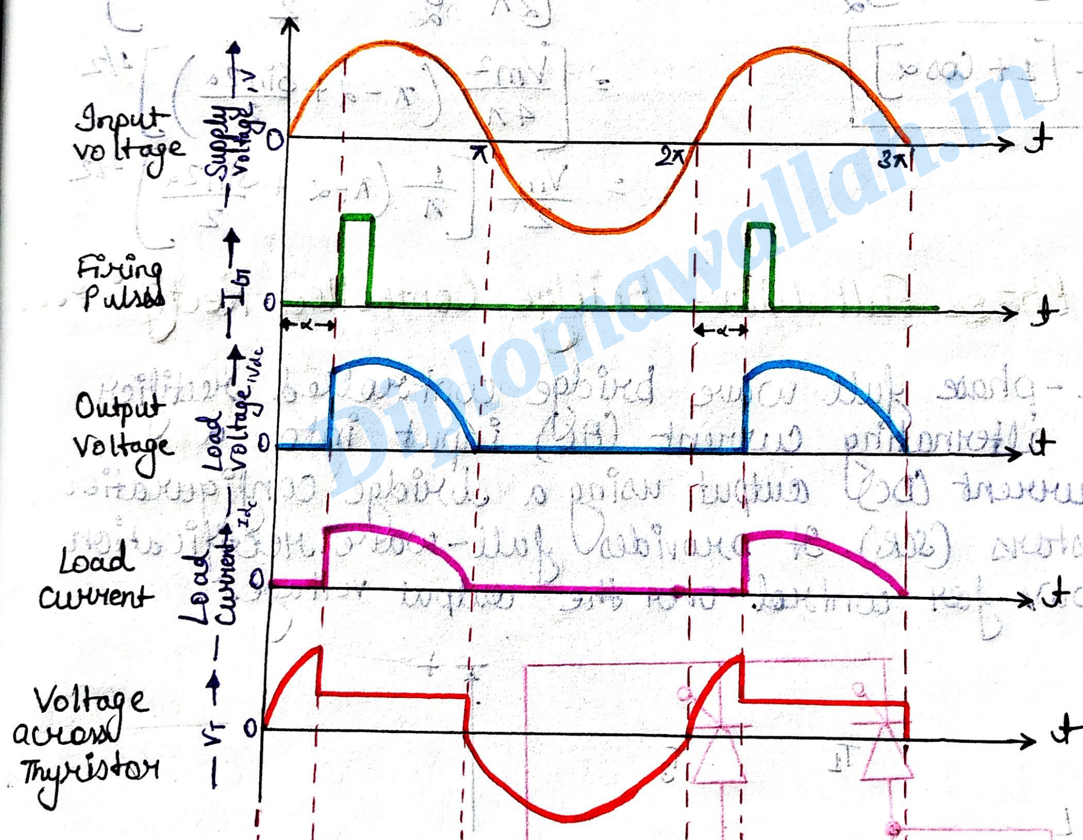




Single Phase Half-Wave Controlled Rectifier...

- Single phase half wave controlled rectifier is a type of thyristor circuit that generates the output voltage in positive half cycle of supply.
- This is circuit diagram which consist of source voltage, thyristor, load resistance.





Working :-

- During positive half cycle voltage drops across thyristor i.e. Vt.

- When voltage drops at that time thyristor don't work due to lack of gate triggering.
- When we applied get pulse by an get terminal then thyristor comes in working state and current starts to flow across thyristor. i_o is the no load current.
- This is output current (i_o) will flow across load resistance (R) and output voltage will be (V_o).
- During negative half cycle thyristor will not conduct source voltage drops across thyristor (V_T).

→ DC Voltage

$$V_{dc} = \frac{1}{2\pi}\int_{\alpha}^{\pi} V_m \sin\omega t \, d\omega t$$

$$V_{dc} = \frac{V_m}{2\pi}\left[-\cos\omega t\right]_{\alpha}^{\pi}$$

$$\boxed{V_{dc} = \frac{V_m}{2\pi}\left[1+\cos\alpha\right]}$$

→ Rms Voltage

$$V_{rms} = \left[\frac{1}{2\pi}\int_{\alpha}^{\pi} V_m^2 \sin^2\omega t \, d\omega t\right]^{1/2}$$

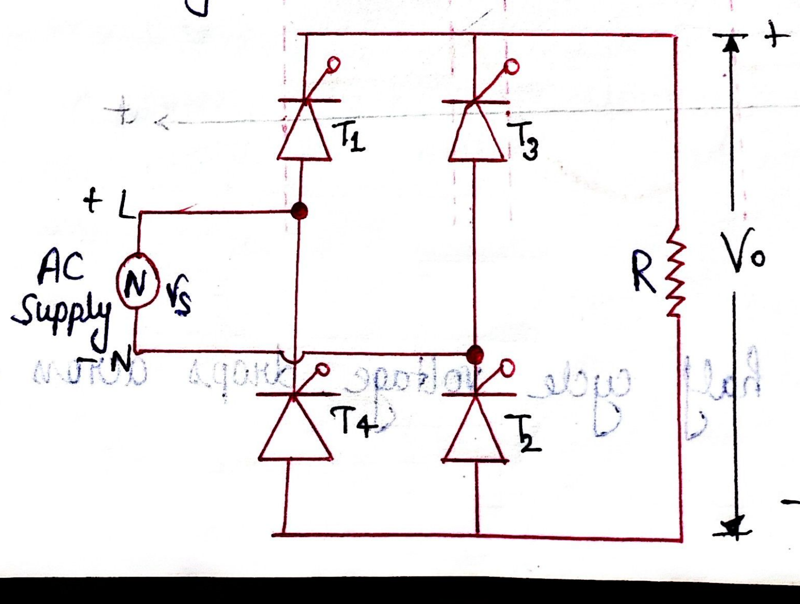
$$= \left[\frac{V_m^2}{2\pi}\int_{\alpha}^{\pi} \frac{1-\cos 2\omega t}{2} \, d\omega t\right]^{1/2}$$

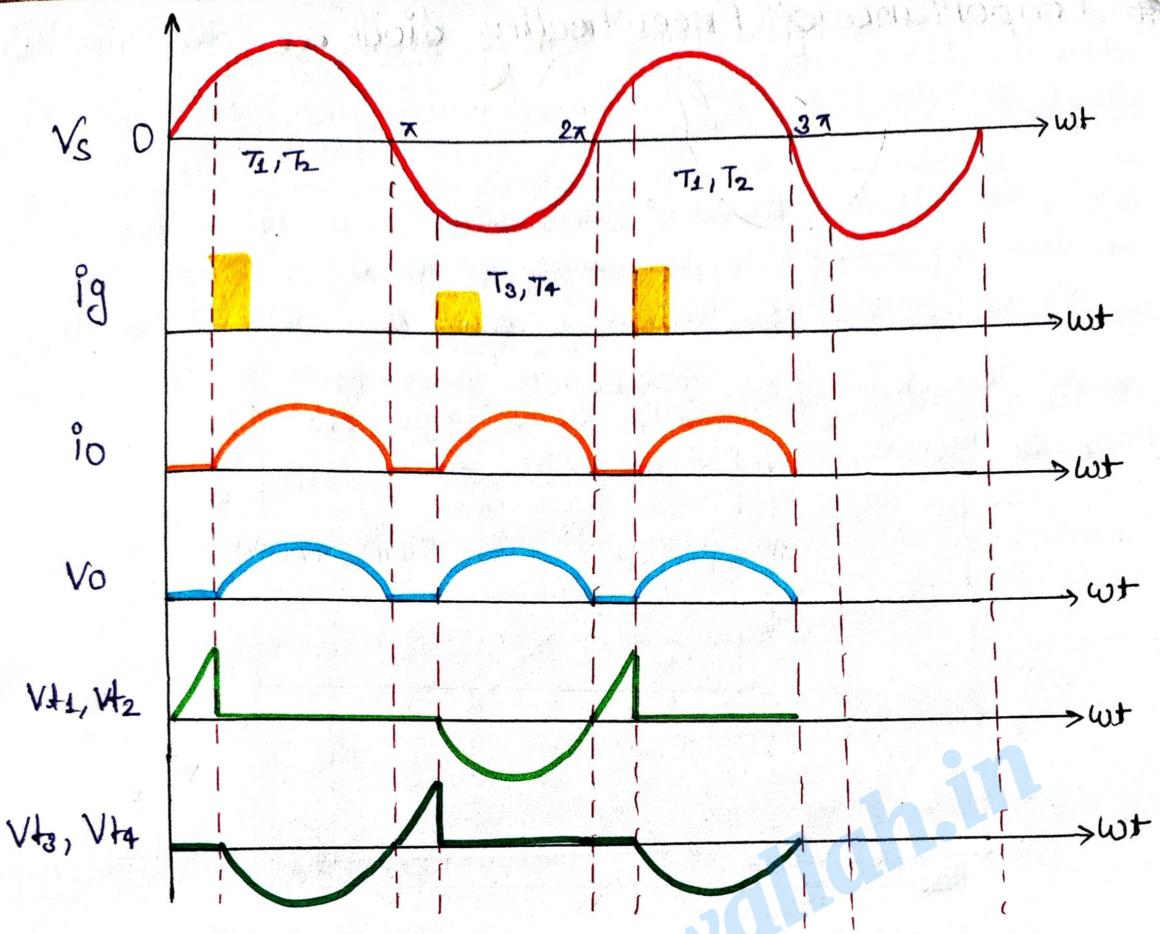
$$= \left[\frac{V_m^2}{4\pi}\left(\pi-\alpha+\frac{\sin 2\alpha}{2}\right)\right]^{1/2}$$

$$= \frac{V_m}{2}\left[\frac{1}{\pi}\left(\pi-\alpha+\frac{\sin 2\alpha}{2}\right)\right]^{1/2}$$

Single Phase Full Wave Bridge Controlled Rectifier...

- A single-phase full wave bridge controlled rectifier converts alternating current (AC) input into a direct current (DC) output using a bridge configuration of thyristors (SCR). It provides full-wave rectification and allows for control over the output voltage.





Working –

- During the first positive half cycle, thyristor T1 and T2 are forward biased and if they are triggered simultaneously, the current flows through the load via thyristor T1 - load T2 - source. Thus, during positive half cycle, thyristor T1 and T2 are conducting.
- During negative half cycle of the ac input, thyristor T3 and T4 are forward biased and if they are triggered simultaneously, the current flows through the load via thyristor T3 - load T4 - source.
- Thyristors T_1, T_3 and T_2, T4 are triggered at the same firing angle α in each positive and negative half cycles of the supply voltage respectively.
- When the supply voltage falls to zero. Thus thyristors T_1, T_2 in positive half cycle and T_3 and T_4 in negative half cycle turn off by natural commutation.