UNIT - IV

CONTROLLED RECTIFIER

One pulse Convertor → Half wave Rectifier

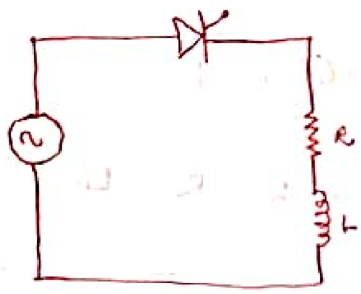
two pulse convertor → Full wave Rectifier & Bridge Rectifier

three pulse Converter → 3p Bridge Rectifier [SCR & Diode]

Six pulse Converter → 3ϕ Bridge Rectifier [SCR only].

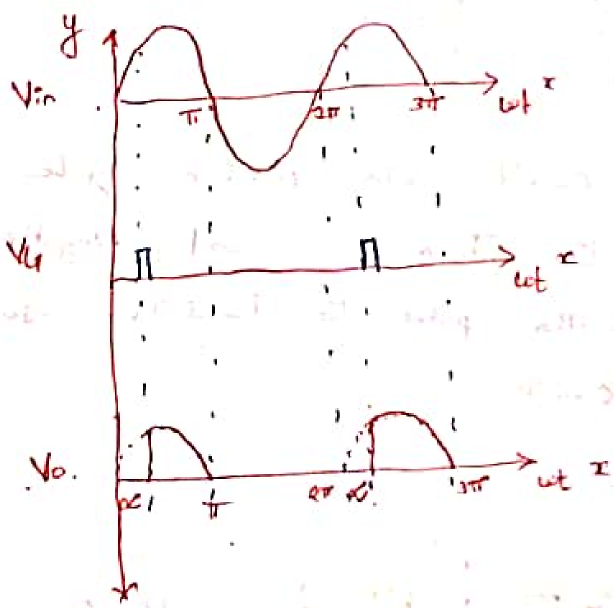
One pulse Converter

Circuit diagram.



In this circuit we give one pulse to SCR T, So its called one pulse Converter. Circuit

Wave form.



Average output Voltage

$$V_o = \frac{\text{Area under the curve}}{\text{Time period}}$$

$$V_{o(AV)} = \frac{1}{2\pi}\int_{\alpha}^{\beta} V_m \sin\omega t \, d\omega t$$

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

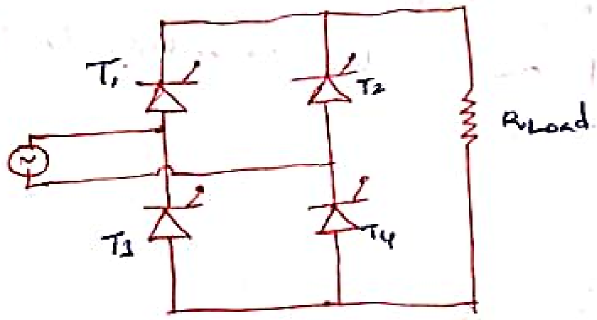
$$= \frac{V_m}{2\pi}\left[-\cos\omega t\right]_{\alpha}^{\beta}$$

$$= \frac{V_m}{2\pi}\left[-\cos\beta + \cos\alpha\right]$$

$$V_{o(AV)} = \frac{V_m}{2\pi}\left[\cos(\alpha - \beta)\right]$$

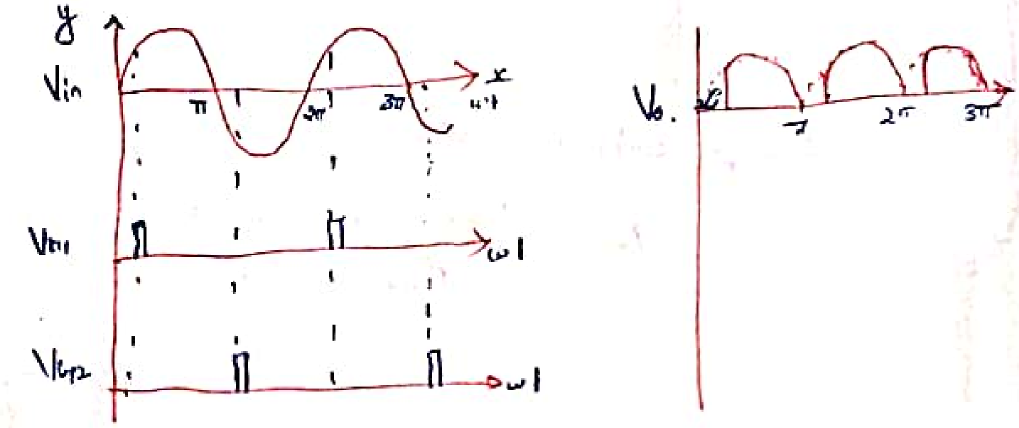
2 pulse Converter with R Load.

Circuit diagram.



In this Circuit for positive cycle we give one pulse to T_1 & T_4 and Negative cycle we give another pulse to T_2 & T_3. So it is called 2 pulse Circuit.

waveforms.



Average out put Voltage

$$V_{o(AV)} = \frac{\text{Area under the curve}}{\text{Time period}}$$

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

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

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

$$= \frac{V_m}{\pi}\left[-\cos\pi + \cos\alpha\right]$$

$$V_{o(AV)} = \frac{V_m}{\pi}\left[1+\cos\alpha\right]$$

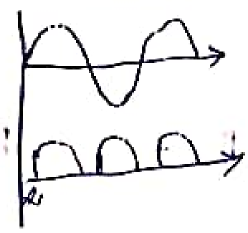
Diode

R RL

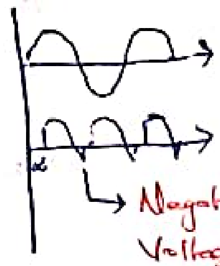
SCR

R RL

SCR R



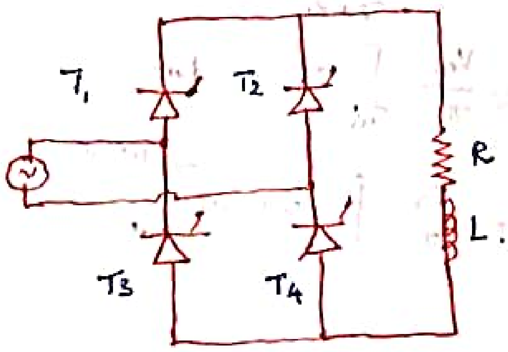
SCR RL



Negative Voltage caused by L effect

2 pulse Converter with RL load.

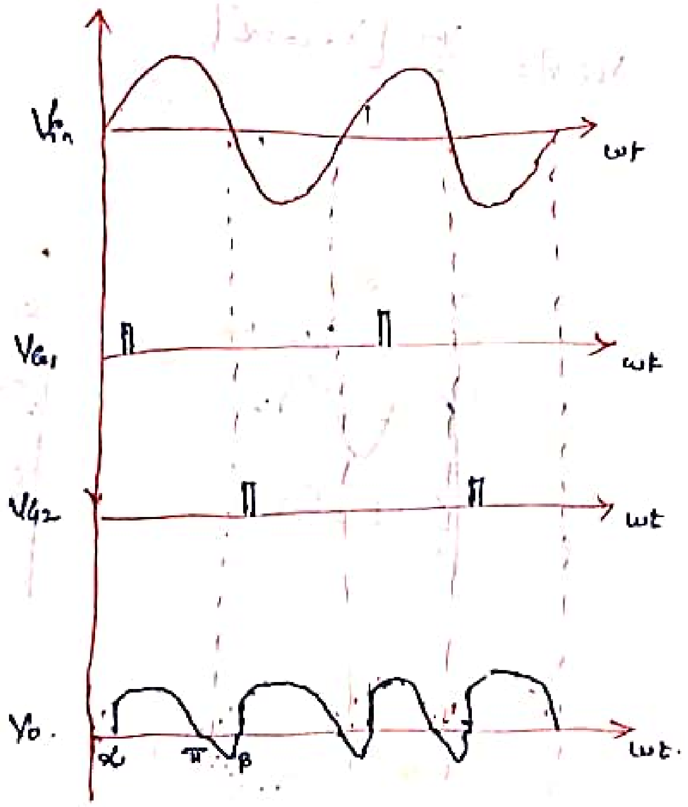
Circuit diagram.



In this Circuit 2 pulse given to the T_1 & T_4 and T_2, T_3. So its also Called 2 pulse Converter Circuits.

But in RL load in inductive nature the load current lagging with Voltage. So thyristor did not turn off on zero Crossing Voltage. This problem avoided by using free wheeling diode across load ~~Resistance~~ R_L.

wave form:



Average o/p Voltage

$$V_{o(AV)} = \frac{V_m}{\pi} \int_{\alpha}^{\pi+\alpha} \sin\omega t \, d\omega t$$

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

$$= \frac{V_m}{\pi}\left[\cos\alpha - \cos(\pi+\alpha)\right]. \qquad \cos(\pi+\alpha) = -\cos\alpha$$

$$= \frac{V_m}{\pi}\left[\cos\alpha - (-\cos\alpha)\right]$$

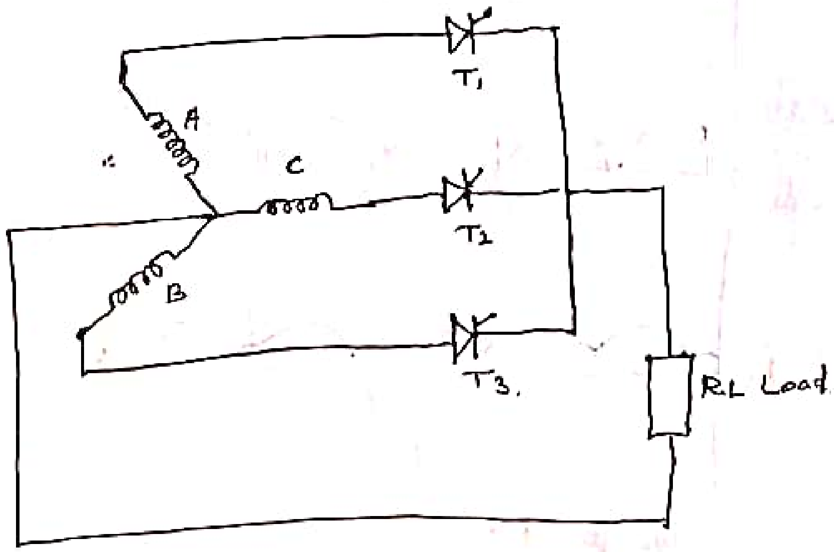
$$= \frac{V_m}{\pi}\left[2\cos\alpha\right]$$

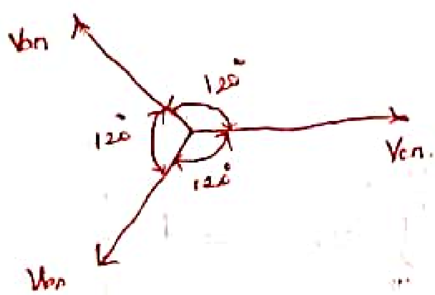
$$V_{o(AV)} = \frac{2V_m}{\pi}\cos\alpha.$$

3 pulse Converter:

- In 3ϕ supply per phase we need atleast 3 SCR, so pulse/scr we give 3 pulse for this Circuit. So its Called 3 pulse Converter.

Circuit diagram.





$V_{an} = V_m \sin\omega t$

$V_{bn} = V_m(\sin\omega t + 120°)$

$V_{cn} = V_m(\sin\omega t + 240°)$

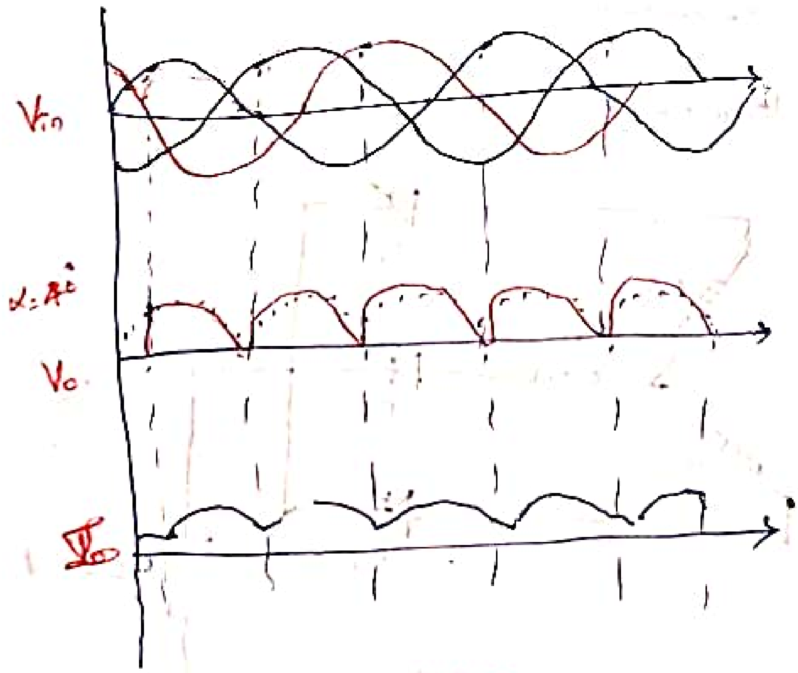
* Thyristor with highest forward biased Voltage will have the priority to Conduct first

* Each thyristor will Conduct a duration of 120° (or) $\frac{2\pi}{3}$ radians, Sequentially.

* Load inductance is Very large & α is Very Small Continuity of load current still maintained

* Load inductance is small & α is Very high Continuity of load Current will not maintained.

Waveform.



Average Rms Voltage.

$$V_{dc} = V_0 (av)$$

$$V_{dc} = \frac{1}{\frac{2\pi}{3}}$$

$$V_{dc} = \frac{3}{2\pi}\left[\int_{\frac{\pi}{6}+\alpha}^{\frac{5\pi}{6}+\alpha} V_m \sin\omega t \, d\omega t\right]$$

$$V_{dc} = \frac{3V_m}{2\pi}\left[\int_{\pi/6+\alpha}^{\frac{5\pi}{6}+\alpha} \sin\omega t \, d\omega t\right]$$

$$V_{dc} = \frac{3V_m}{2\pi}\left[-\cos\omega t\right]_{\pi/6+\alpha}^{\frac{5\pi}{6}+\alpha}$$

$$V_{dc} = \frac{3V_m}{2\pi}\left[-\cos\left(\frac{5\pi}{6}+\alpha\right) + \cos\left(\frac{\pi}{6}+\alpha\right)\right]$$

$\cos(A+B) = (\cos A \cos B - \sin A \sin B)$

$$V_{dc} = \frac{3V_m}{2\pi}\left[-\cos\frac{5\pi}{6}\cos\alpha + \sin\frac{5\pi}{6}\sin\alpha + \cos\frac{\pi}{6}\cos\alpha - \sin\frac{\pi}{6}\sin\alpha\right]$$

$$V_{dc} = \frac{3V_m}{2\pi}\left[-\cos 150^\circ \cos\alpha + \sin 150^\circ \sin\alpha + \cos 30^\circ \cos\alpha - \sin 30^\circ \sin\alpha\right]$$

Co

$$V_{dc} = \frac{3V_m}{2\pi}\left[-\cos(180^\circ-30^\circ)\cos\alpha + \sin(180^\circ-30^\circ)\sin\alpha + \cos 30\cos\alpha - \sin 30 \sin\alpha\right]$$

Note $\cos(180^\circ-30^\circ) = -\cos 30^\circ$

$\sin(180^\circ-30^\circ) = \sin 30^\circ$

$$= \frac{3V_m}{2\pi}\left[+\cos 30^\circ\cos\alpha + \sin 30^\circ \sin\alpha + \cos 30\cos\alpha - \sin 30 \sin\alpha\right]$$

$$V_{dc} = \frac{3V_m}{2\pi}\left[2\cos 30 \cos\alpha\right]$$

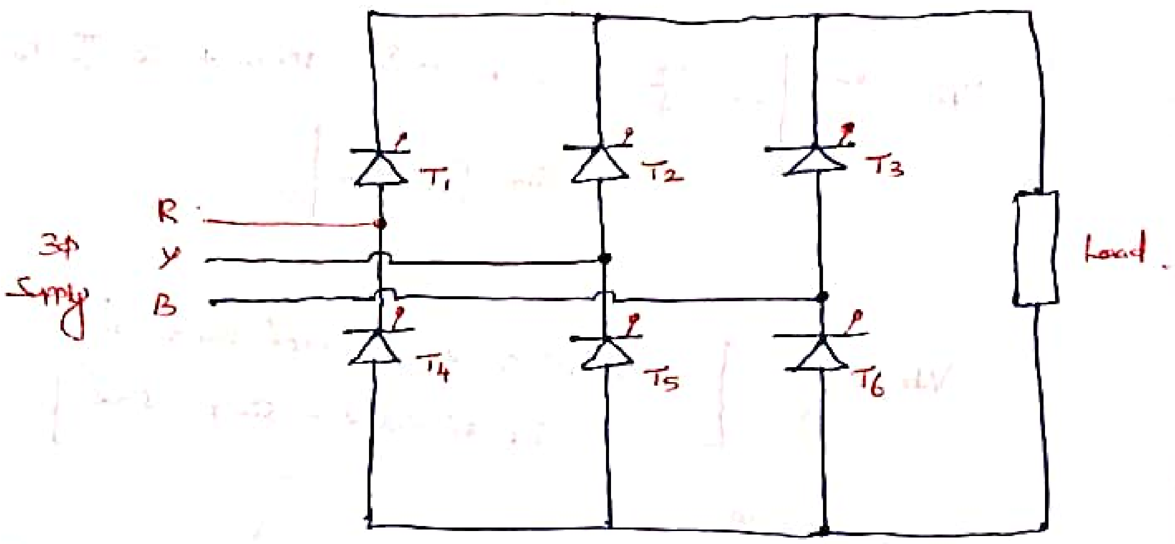
$$V_{dc} = \frac{3V_m}{2\pi}\left[2 \times \frac{\sqrt{3}}{2}\cos\alpha\right]$$

$$V_{dc} = \frac{3\sqrt{3}V_m}{2\pi}\cos\alpha$$

6 pulse converter:

In this diagram 6 SCRs we give separately pulse/SCR. So this Circuit is Called Six pulse Converter Circuit.

Circuit diagram:.



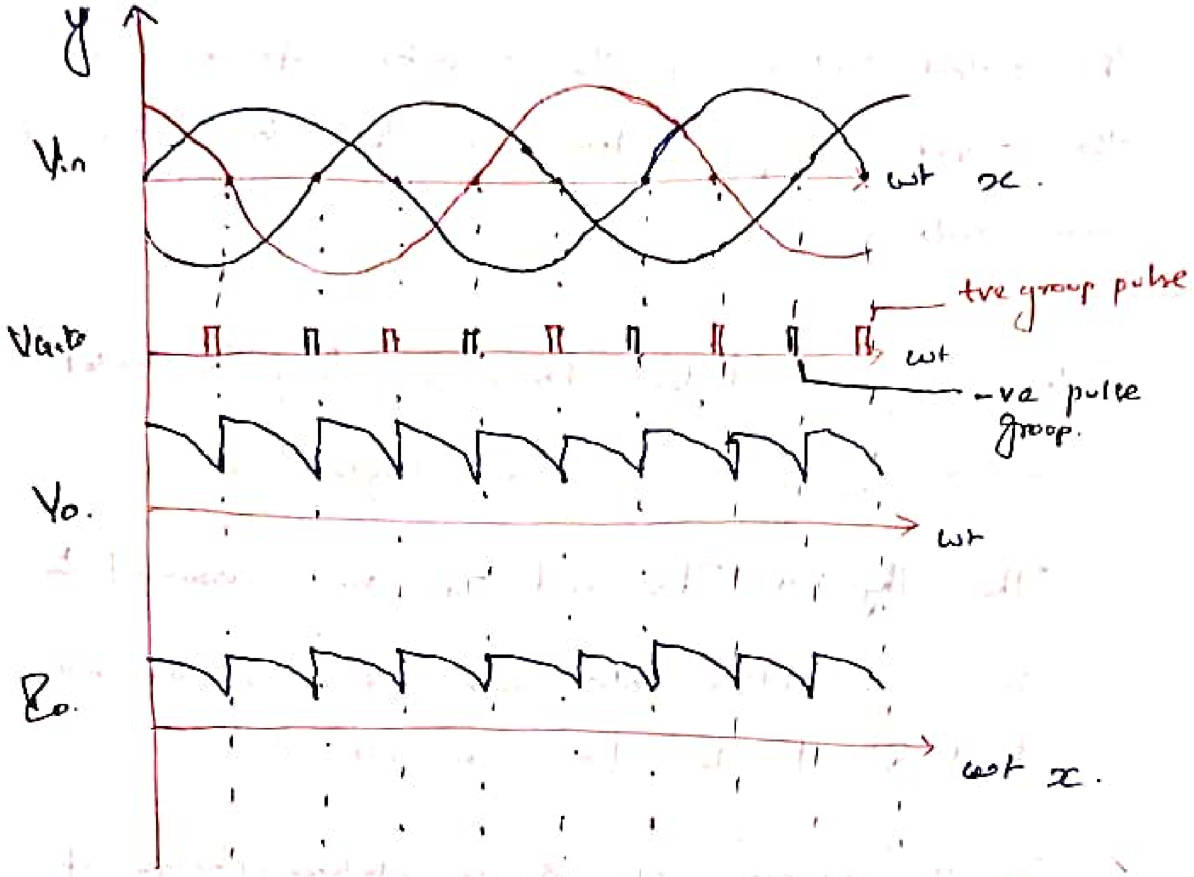
* A Six pulse bridge Converter obtained By connecting a 2 three pulse converters in parallel. One group is for positive and the another one is used for Negative.

* At all times two thyristors one is positive side and the another one Negative side are working.

* If firing angle below 90° power flows from Source to load

* If firing angle above 90° power flows from Load to Source.

wave form:

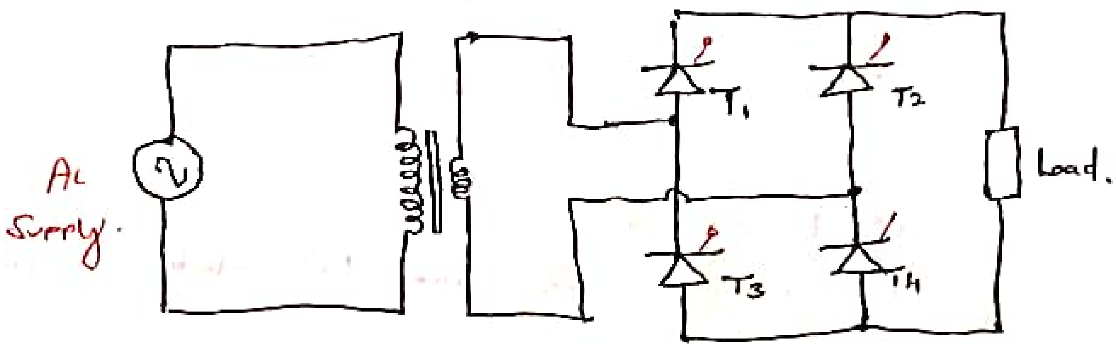


Average o/p Voltage.

Same as 3 pulse converter.

Effect of Source Inductance.

Circuit diagram.

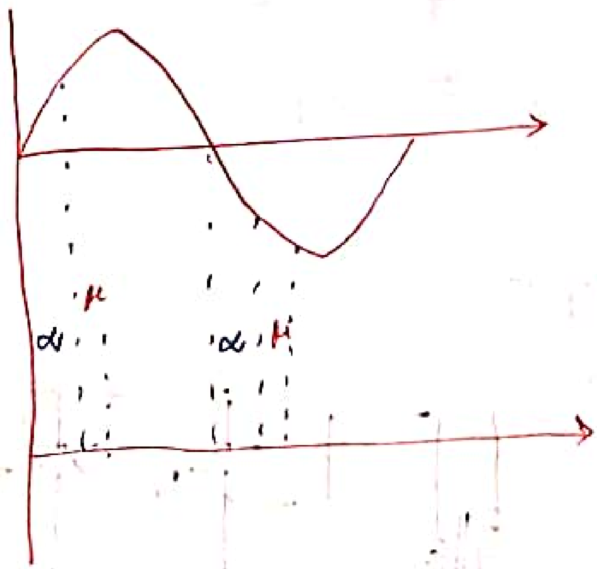


Source inductance has a significant impact on the converter performance because its presence alters the output voltage of the converter. As a result the output voltage reduces, as the load current also reduces.

The diagram below shows a fully controlled converter with source in single phase.

The thyristors T_3 and T_4 are assumed to be in conduction mode when $t=0$. On the other hand T_1 and T_2 fire when $\omega t = \alpha$.

In the presence of source inductance, change of polarity and commutation does not occur instantaneously.



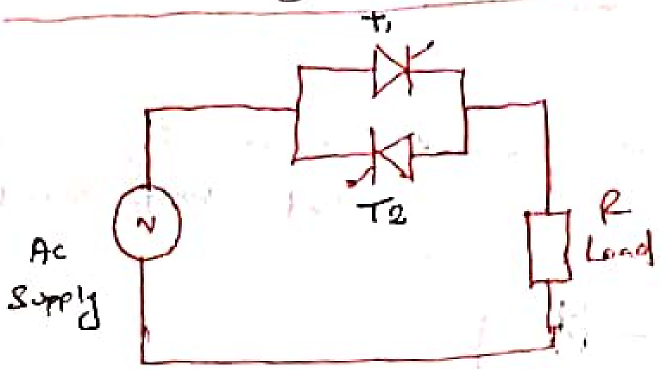
α = Firing angle

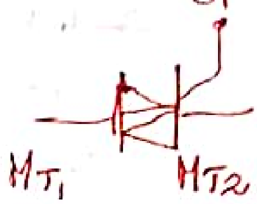
μ = overlab angle due to inductance effect

UNIT-V

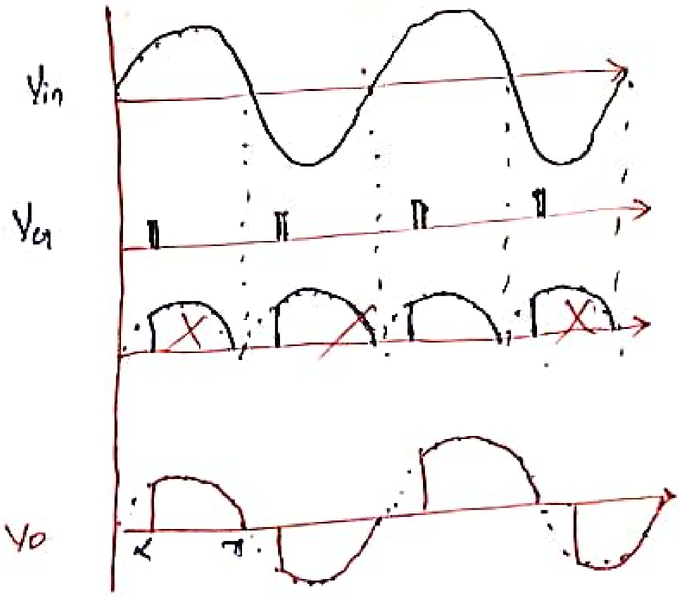
AC VOLTAGE CONTROLLER.

1Φ Ac Voltage Controller R load.





TRIAC.



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

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

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

$$= \frac{V_m}{\pi}\left[-\cos\pi + \cos\alpha\right]$$

$$= \frac{V_m}{\pi}\left[1+\cos\alpha\right].$$

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

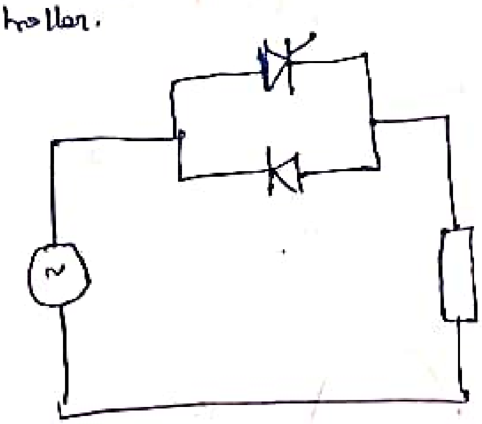
$$V_{rms} = \left[\frac{1}{\pi}\int_{\alpha}^{\pi} V_m^2 \sin^2\omega t \, d\omega t\right]^{1/2}$$

Uni directional mode & Bidirectional mode.

Half wave Control & full wave Control.

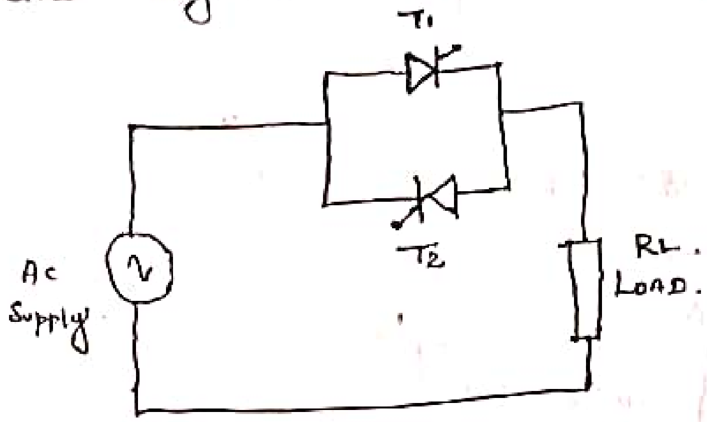
In uni directional mode only one SCR is Conduct so we used. Connected with diode in parallel.

So we control the Ac power in +ve half cycle only. So its Called ~~Bidi~~ uni directional Controller.

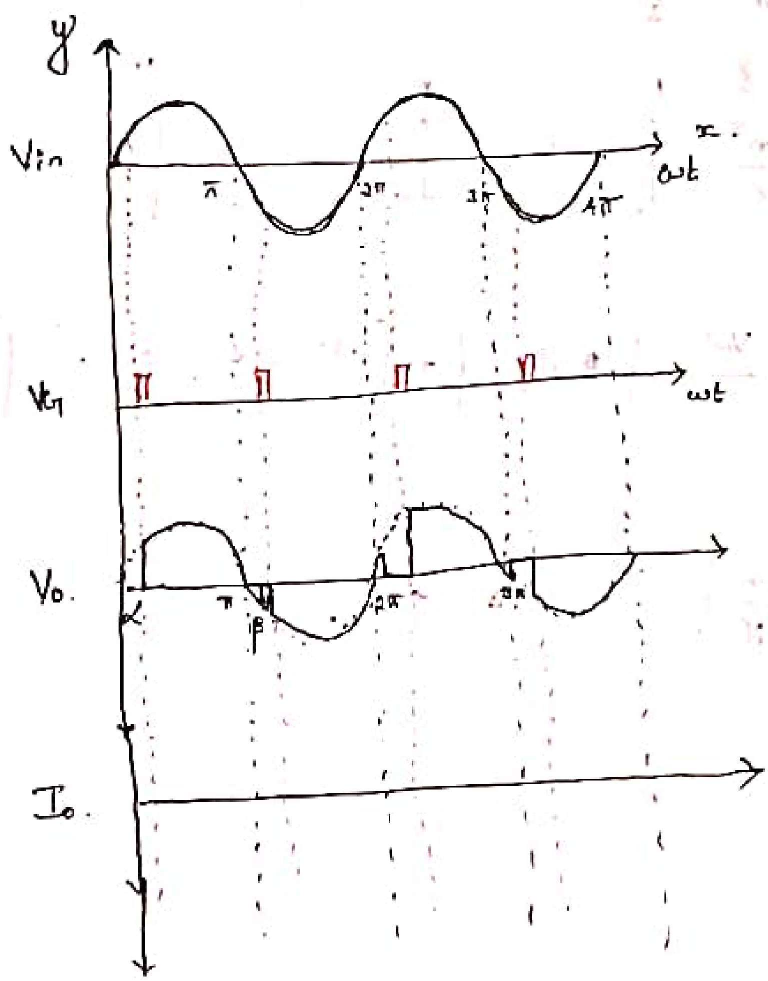


1Φ Ac Voltage Controller with RL Load

Circuit diagram.



Waveform.



$$V_{rms} = \left[\frac{1}{T} \int_0^T V_o^2 \omega t \, d\omega t \right]^{1/2}$$

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

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

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

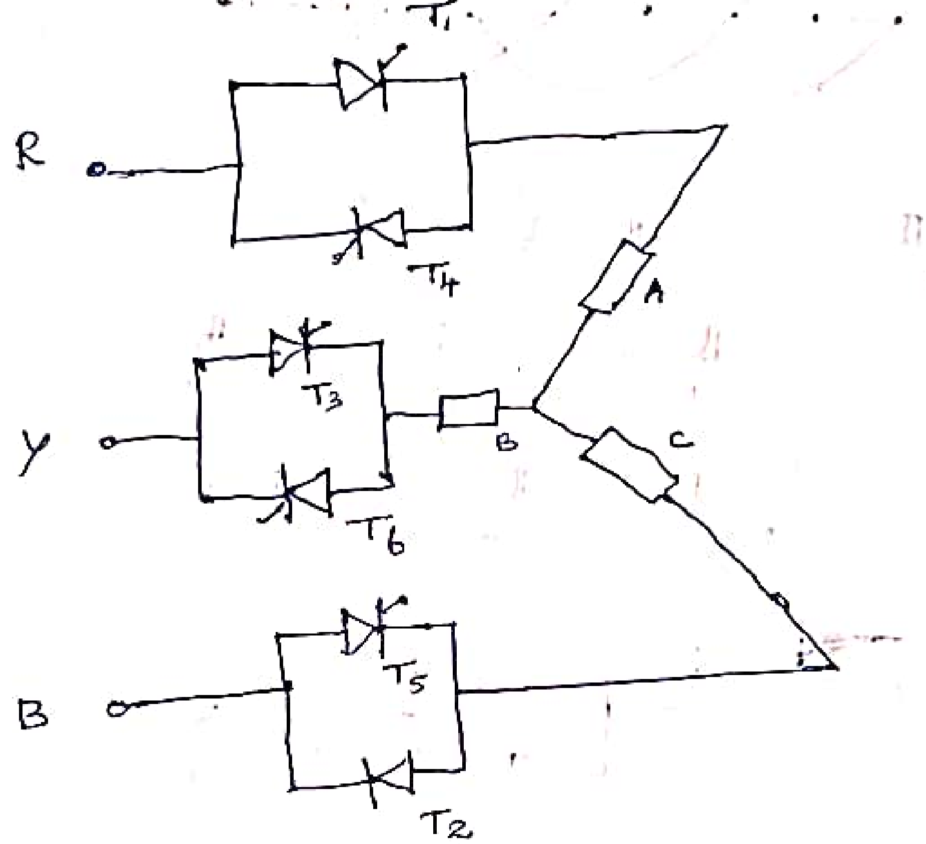
$$= \left[\frac{V_m^2}{\pi} \int_\alpha^\beta \omega t \, d\omega t - \int_\alpha^\beta \cos 2\omega t \, d\omega t \right]^{1/2}$$

$$V_{o\,rms} = \left[\frac{V_m^2}{\pi} [\beta - \alpha] + \left[\frac{\sin 2\alpha}{2} - \frac{\sin 2\beta}{2} \right] \right]^{1/2}$$

$$V_{o\,rms} = \frac{V_m}{\sqrt{\pi}} .$$

3 phase Ac Voltage Controller.

Circuit diagram:

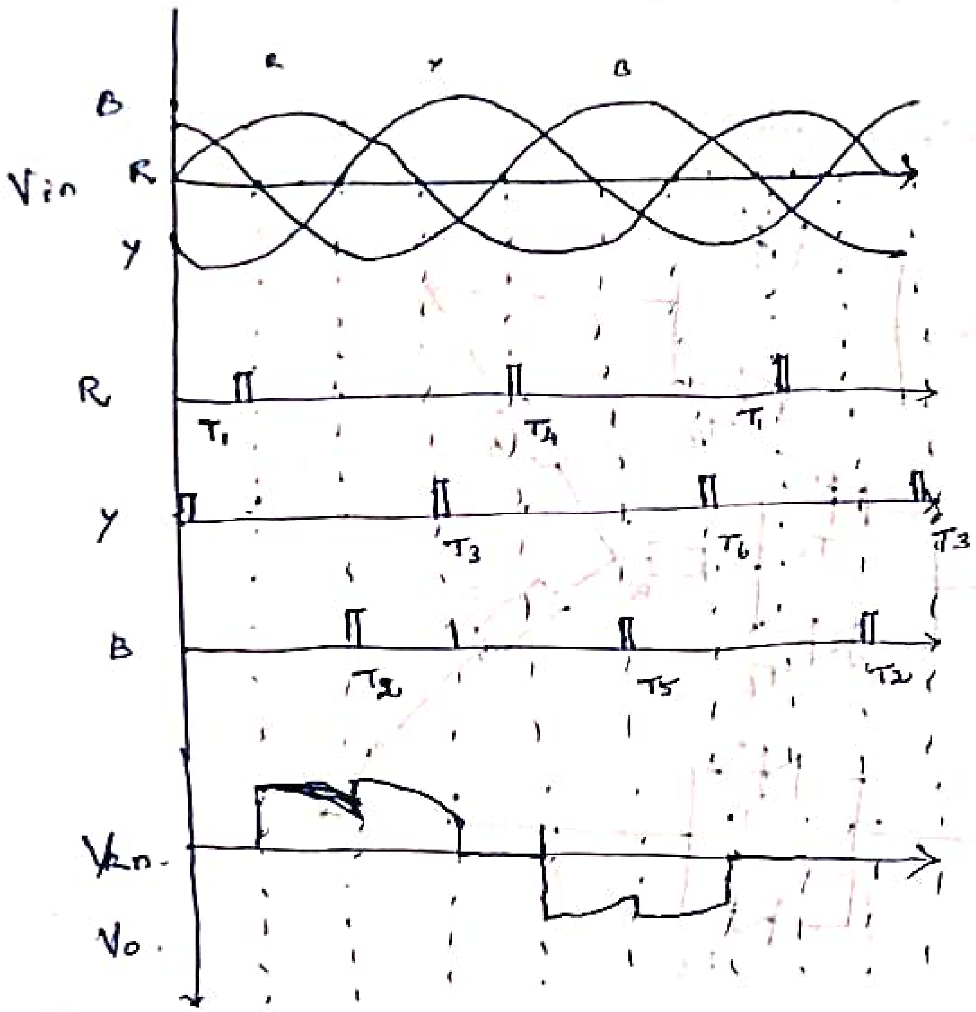


3ϕ AC Voltage Controllers can be utilized to provide 3ϕ Ac ~~Voltage~~ load to Control the Various operations.

T_1, T_3, T_5 is a Group of Positive sequence SCR.

T_4, T_6, T_2 is a Negative Sequence SCR.

Firing Sequence of SCR's are.



Applications.

* speed control of AC motors.
* Industrial heating furnaces
* Fan & light controls.