UNIT - II

Date 26/07/19

Single Phase Controlled Converters (AC-DC)

→ It always single phase A.c voltage.

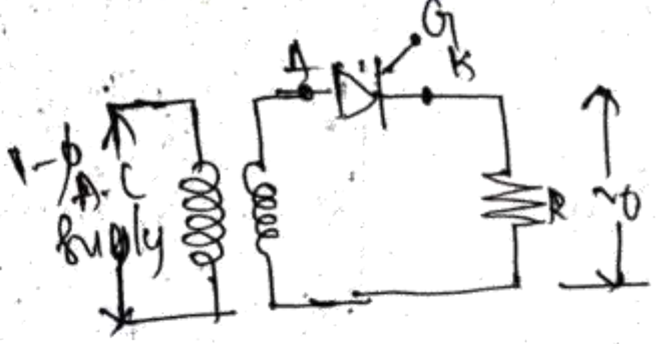
→ that A.c voltage is converted into average D.C.

→ Single phase A.c is converted to D.C. that is mainly two parts

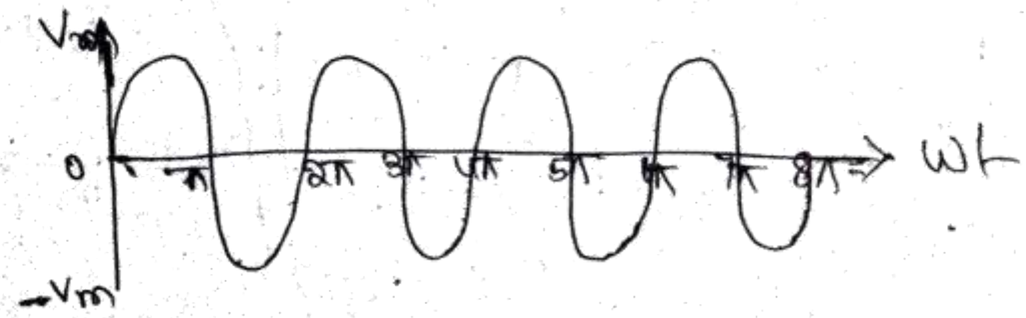
(i) 1-ϕ half wave converter -- low power application

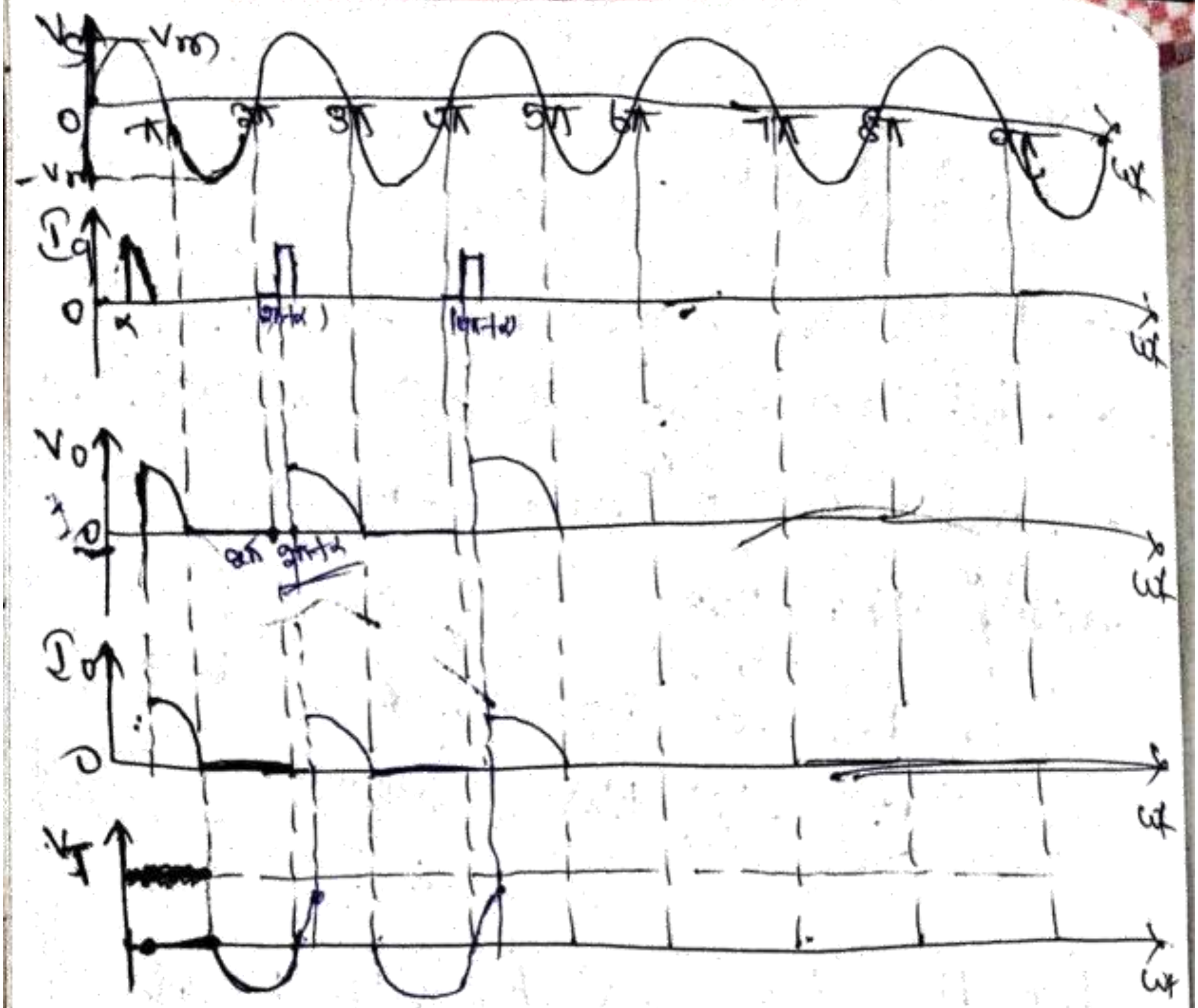
(ii) 1-ϕ full wave converter - full power application

(i) 1-ϕ Half Wave Conductor With "R" load !-



1. All the SCR's are treated as ideal devices
2. We have to assume Gate signal is present in the device





→ It gives more o/p voltage [firing angle]

$I_{rms} = \frac{V_{orms}}{R}$

$$V_o = \frac{1}{2\pi}\int_{\alpha}^{\pi} V_s \, d\omega t$$

$$V_s = V_m \sin\omega t$$

$$= \frac{1}{2\pi}\int V_m \sin\omega t \, d\omega t$$

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

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

Mean (or) Average o/p

$$V_o = \frac{1}{2\pi}\int_0^{\pi} V_m \sin\omega t \, d\omega t.$$

RMS value,

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

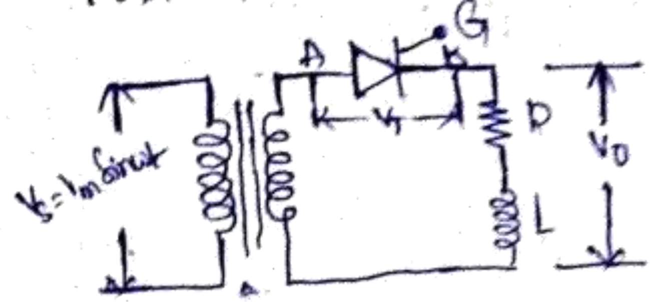
$$= \left[\frac{V_m^2}{2\pi}\int\left[\frac{1-\cos 2\omega t}{2}\right] d\omega t\right]^{1/2}$$

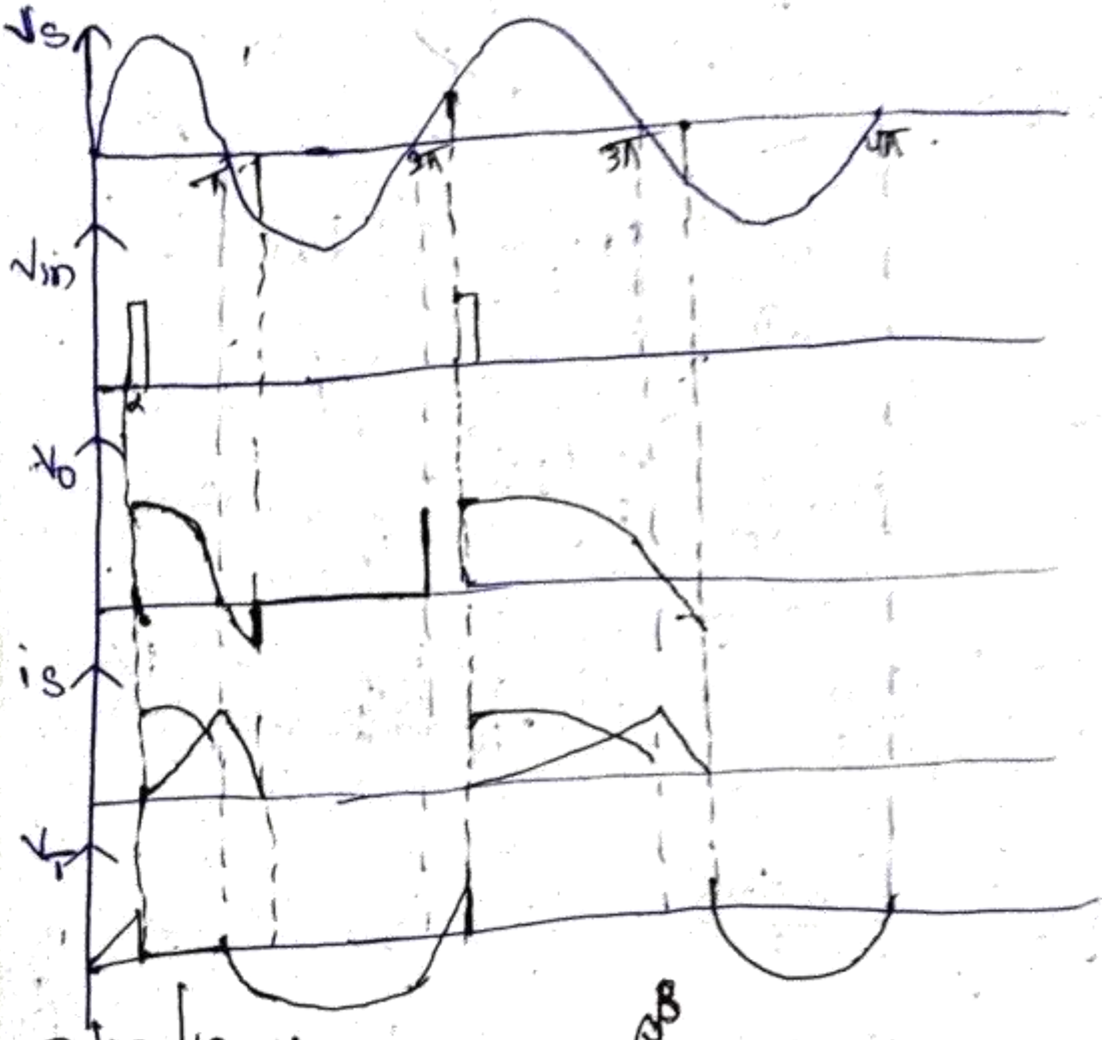
$$= \frac{V_m^2}{2\pi}\left(\{d\omega t\}_0^{\pi} - \frac{1}{2}\sin 2\omega t\Big]_0^{\pi}\right)$$

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

$\Rightarrow \sin\pi = 0.$

* 1-φ half Wave Rectifier With R-L load:-





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$$V_0 = \frac{1}{2\pi}\int_{\alpha}^{\beta} V_m \sin\omega t \, d\omega t$$

$$V_0 = V_m \sin\omega t$$

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

$$V_0 = \frac{V_m}{2\pi}\left(\cos\alpha - \cos\beta\right)$$

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$$i_0 = \frac{V_0}{R} = \frac{V_m}{2\pi R}\left(\cos\alpha - \cos\beta\right).$$

Mean (or) Average:-

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

$$\sin^2\omega t = \frac{1-\cos 2\omega t}{2}.$$

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

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

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

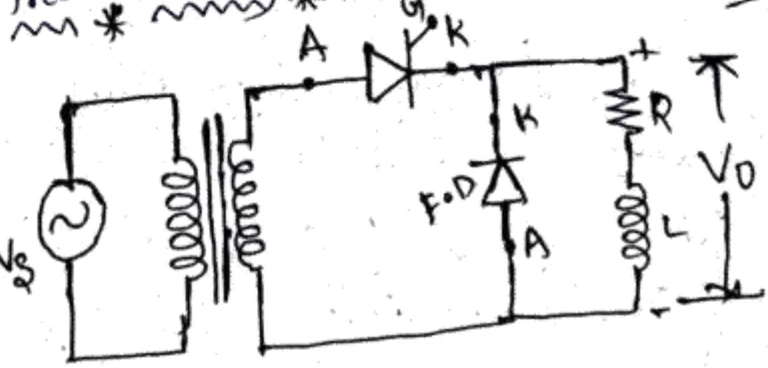
$$I_{orms} = \frac{V_0\,R_{ms}}{R}$$

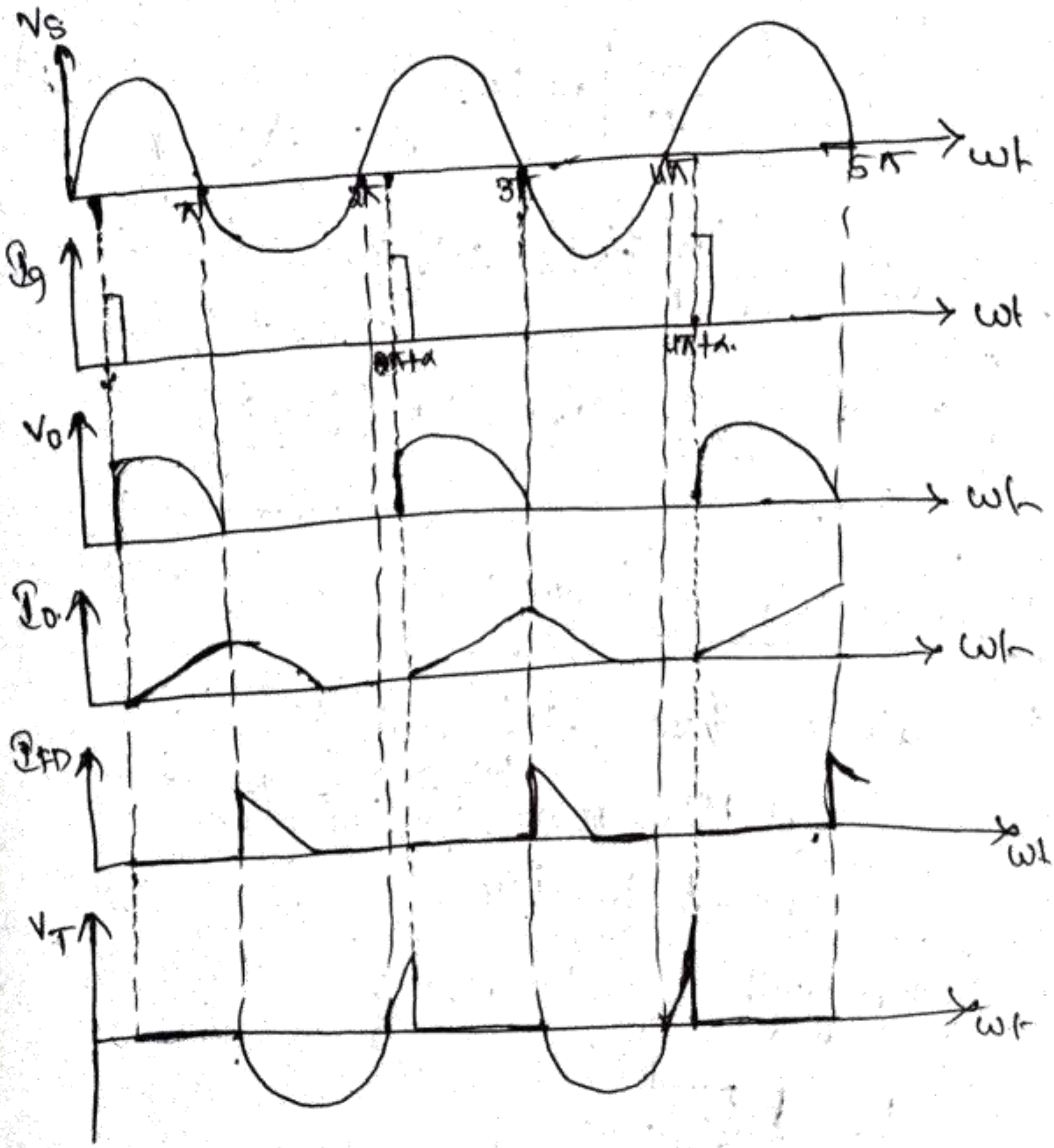
$$= \frac{1}{R}\left[\frac{V_m^2}{4\pi R}\left[(\beta - \alpha) - \frac{1}{2}\left(\sin 2\beta - \sin 2\alpha\right)\right]\right]^{1/2}$$

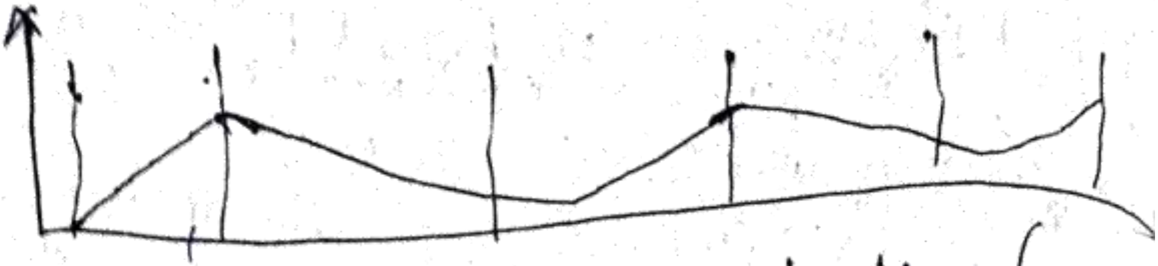
$$\boxed{I_{rms} = \frac{V_m}{2\pi R}\sqrt{(\beta-\alpha) - \frac{1}{2}\left(\sin 2\beta - \sin 2\alpha\right)}}$$

* 1-ϕ Half Wave Converter With R-L Load and free Wheeling diode :-

F.D :- to improve Efficiency, power factor.







Continous Current Mode Wave form.

$$\rightarrow \quad V_0 = \frac{1}{2\pi}\int_{\alpha}^{\pi} V_m \sin\omega t \, d\omega t.$$

$$V_0 = \frac{V_m}{2\pi}\left[1+\cos\alpha\right].$$

$$\boxed{Pf = \frac{V_{orms}}{V_s}}$$

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

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

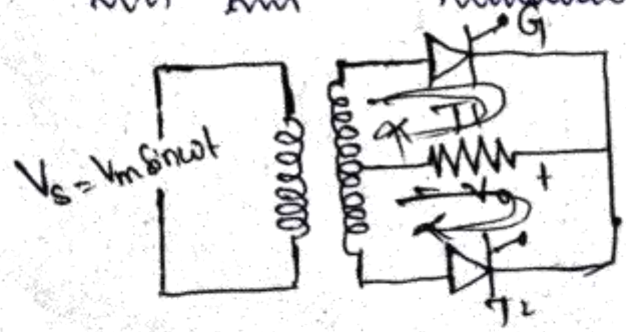
1-ϕ full Wave Converters :-

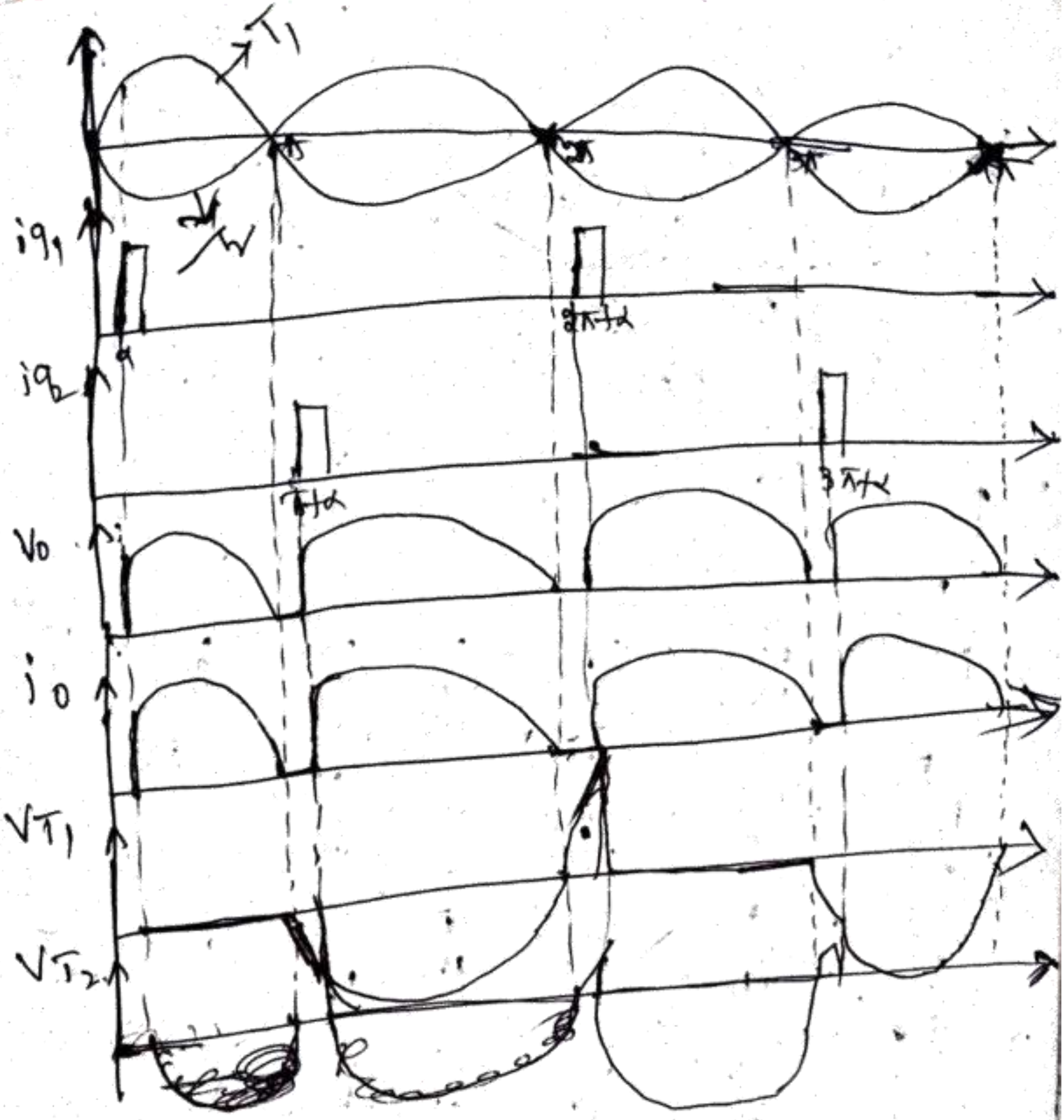
* mainly two types:

(i) Mid point (or) centre-tapped Configuration

(ii) Bridge type.

(i) Mid point Configuration :-





$$V_0 = \frac{2}{2\pi}\int_{\alpha}^{\pi} V_m \sin\omega t \, d\omega t$$

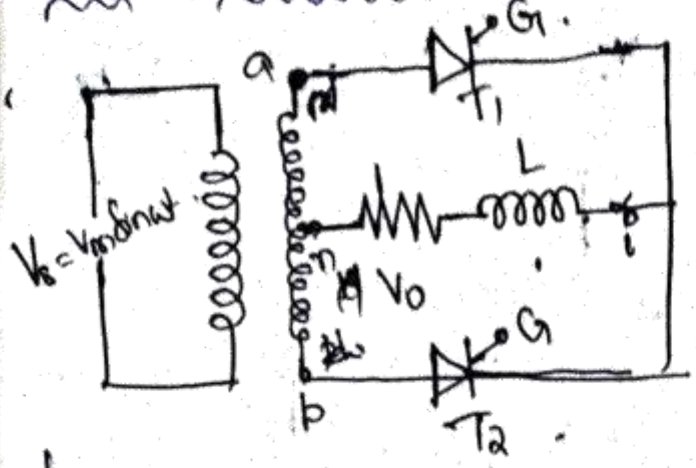
$$\boxed{V_0 = \frac{V_m}{\pi}\left(1+\cos\alpha\right)}$$

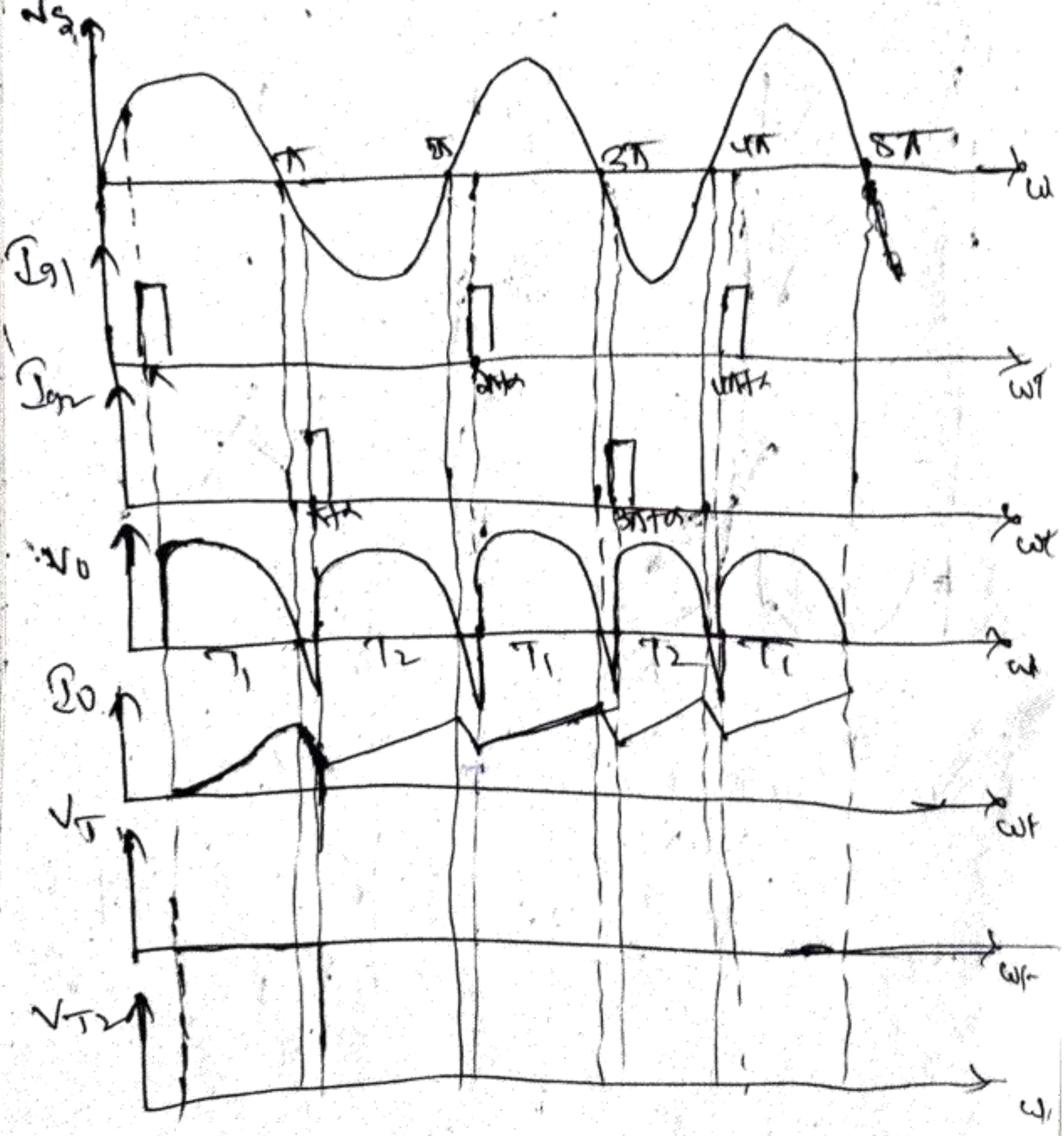
$$\boxed{I_{rms} = \frac{V_{orms}}{R}}$$

$$\boxed{I_0 = V_0/R}$$

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

R-L Configuration :-





$$V_0 = \frac{2}{2\pi}\int_{\alpha}^{\pi+\alpha} V_m \sin\omega t \, d\omega t.$$

$$V_0 = \frac{V_m}{\pi} \int_{\alpha}^{\pi+\alpha} \sin\omega t \, d\omega t$$

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

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

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

$$\boxed{V_0 = \frac{2V_m}{\pi} \cdot \cos\alpha}$$

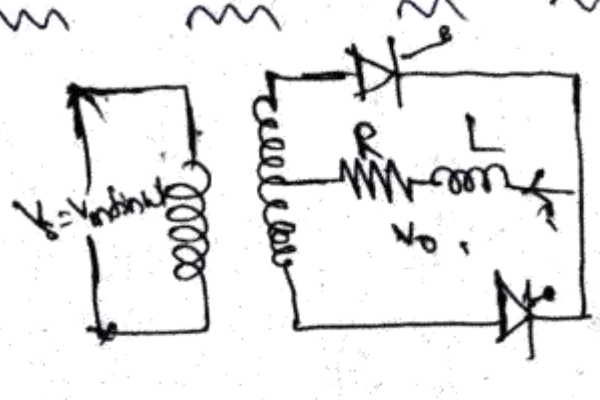
$$\rightarrow \boxed{I_0 = V_0 / R}$$

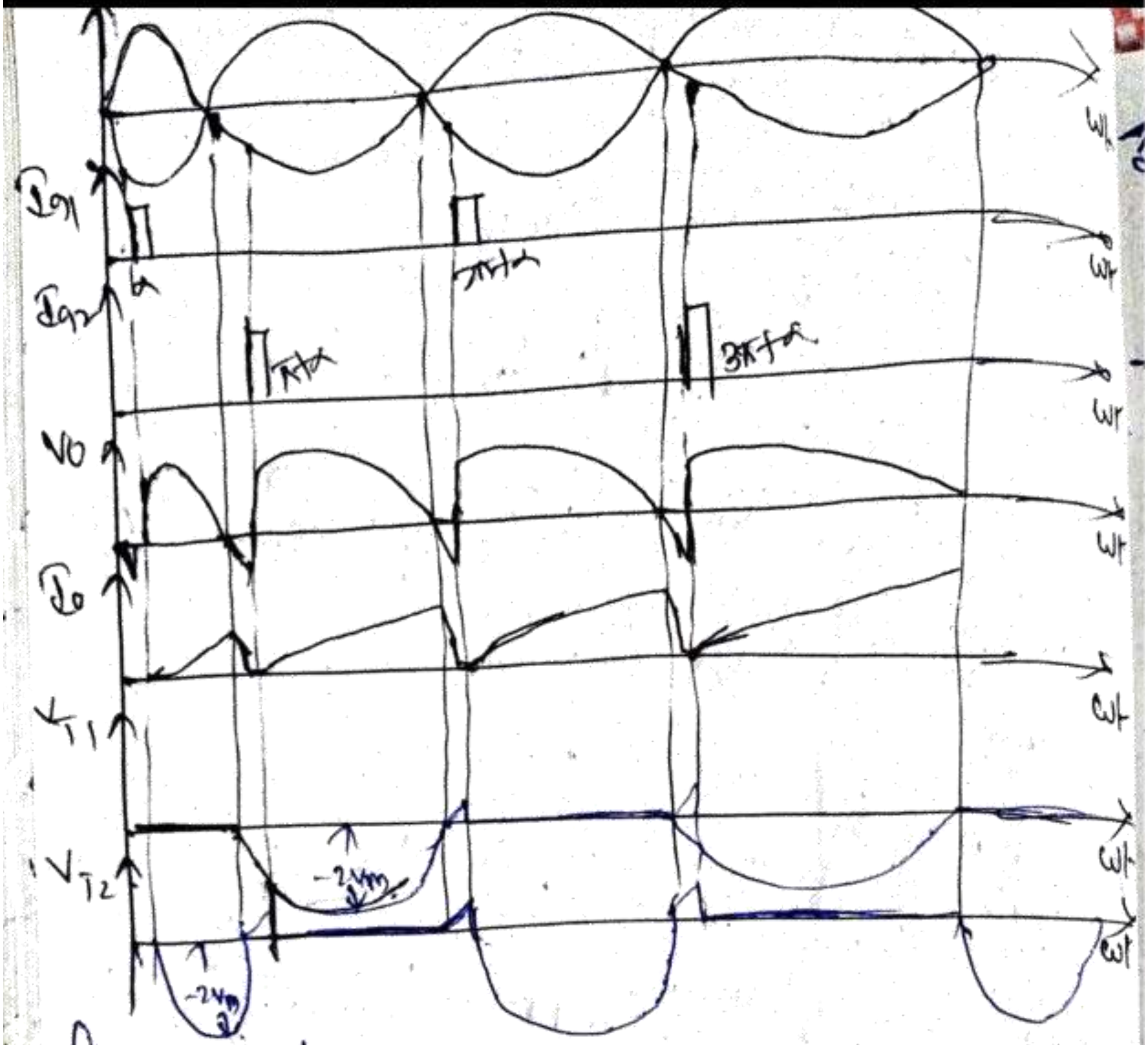
$$\boxed{V_{orms} = \frac{V_m}{\sqrt{\pi}} \left[(\pi) + \tfrac{1}{2}\sin\omega t\right]^{1/2}}$$

$$\boxed{I_{orms} = \frac{V_{orms}}{R}}$$

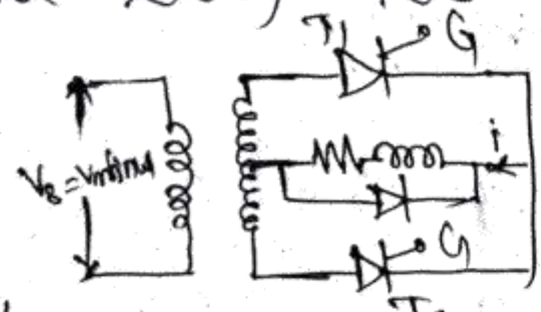
1-ϕ full wave

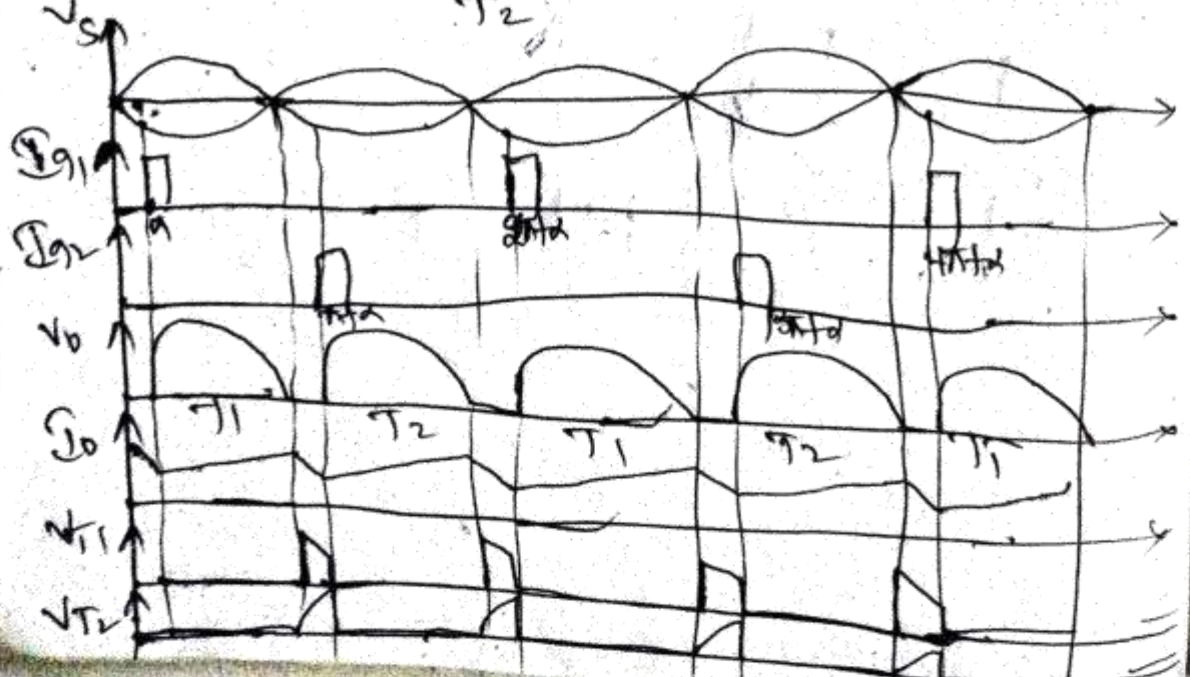
* R-L load and ~~...~~ wheeling :-





Free-Wheeling Diod :-





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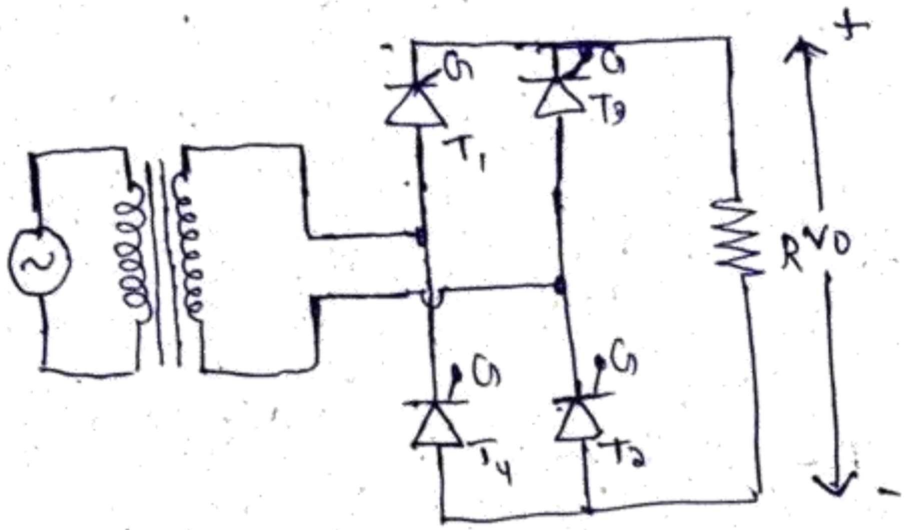
Bridge Configuration:-

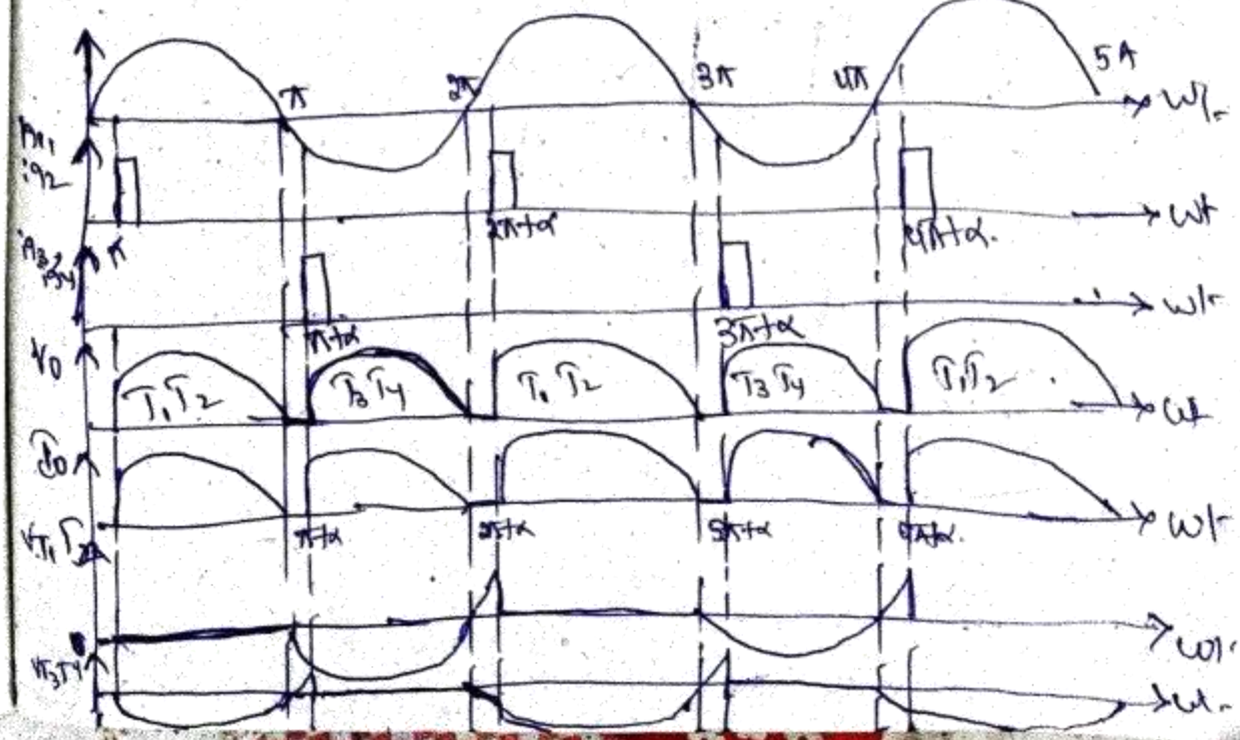
→ The mid point Converter disadvantages are avoided by Bridge Converter.

Single phase Bridge Converter With R-Load:-



→ '0-π' interval T_1, T_2 gets F.B and gets Conduction

- T_3, T_4 not at all Comes to Conduction



$$V_0 = \frac{2}{2\pi} \int_{\alpha}^{\pi} V_m \sin \omega t \, d\omega t$$

$$V_0 = \frac{V_m}{\pi} [1 + \cos\alpha]$$

$$I_0 = \frac{V_0}{R}$$

$$\boxed{I_0 = \frac{V_m}{\pi R} [1 + \cos\alpha]}$$

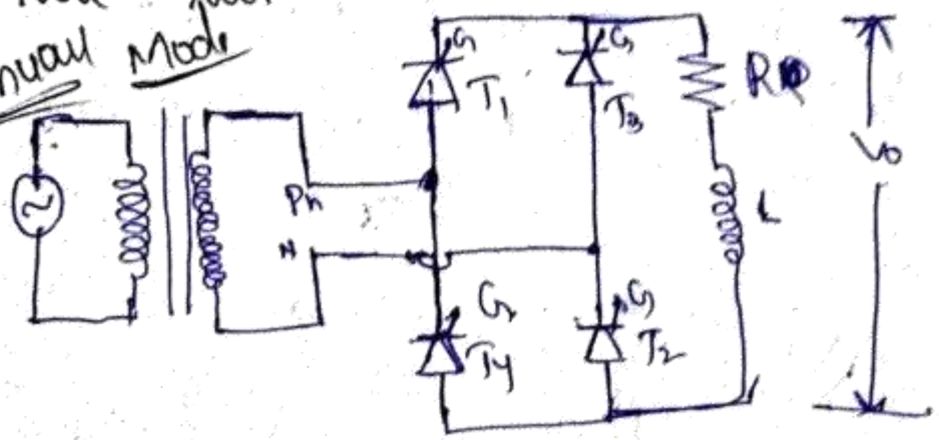
$$\Rightarrow V_{orms} = \left[\frac{2}{2\pi} \int_{\alpha}^{\pi} [V_m \sin \omega t \, d\omega t]^2 \right]^{1/2}$$

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

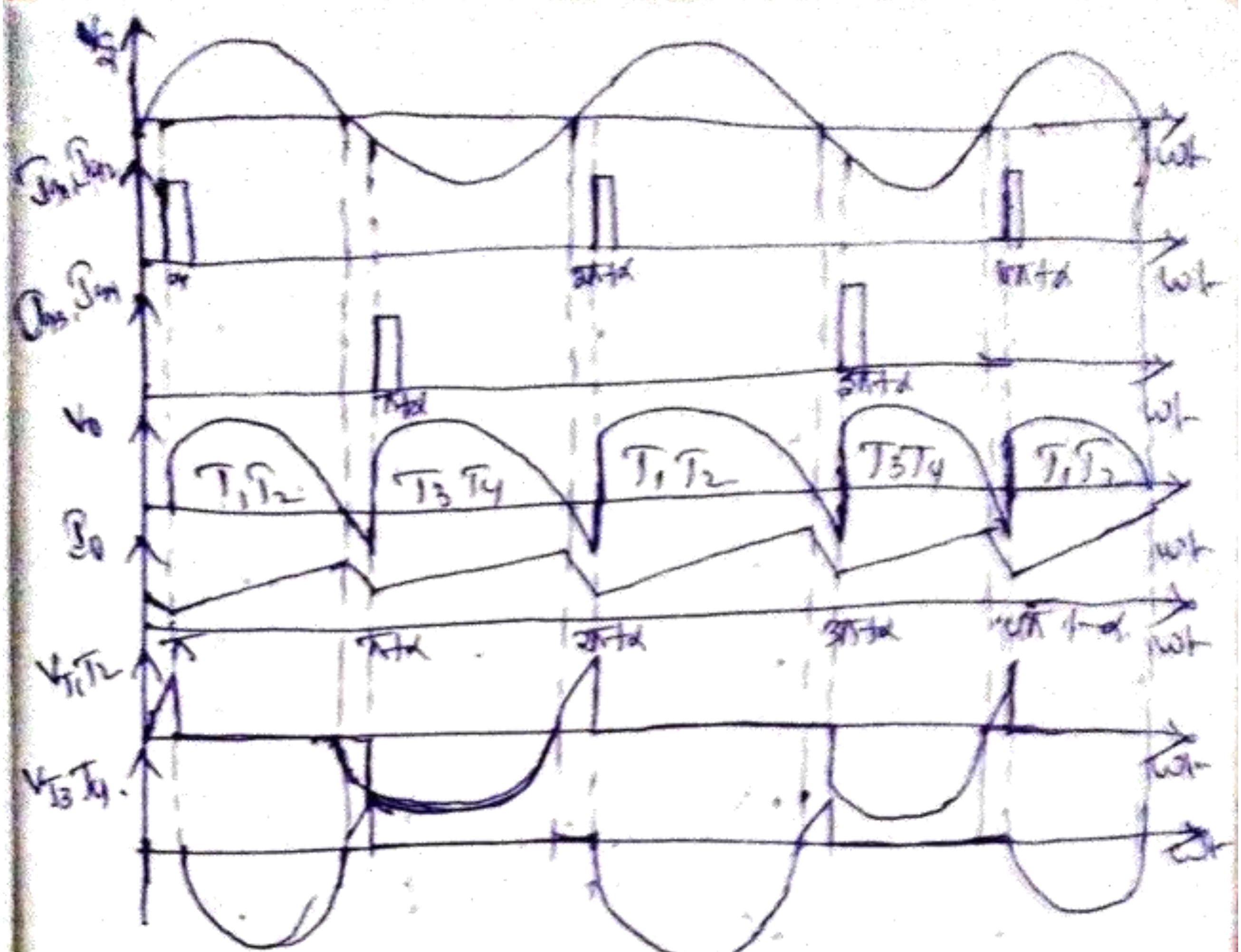
$$I_{orms} = \frac{V_{orms}}{R} = \frac{V_m}{\sqrt{2\pi} R} \left[(\pi - \alpha) + \tfrac{1}{2} \sin \omega t \right]^{1/2}$$

* Single phase Bridge Converter with R-L load:

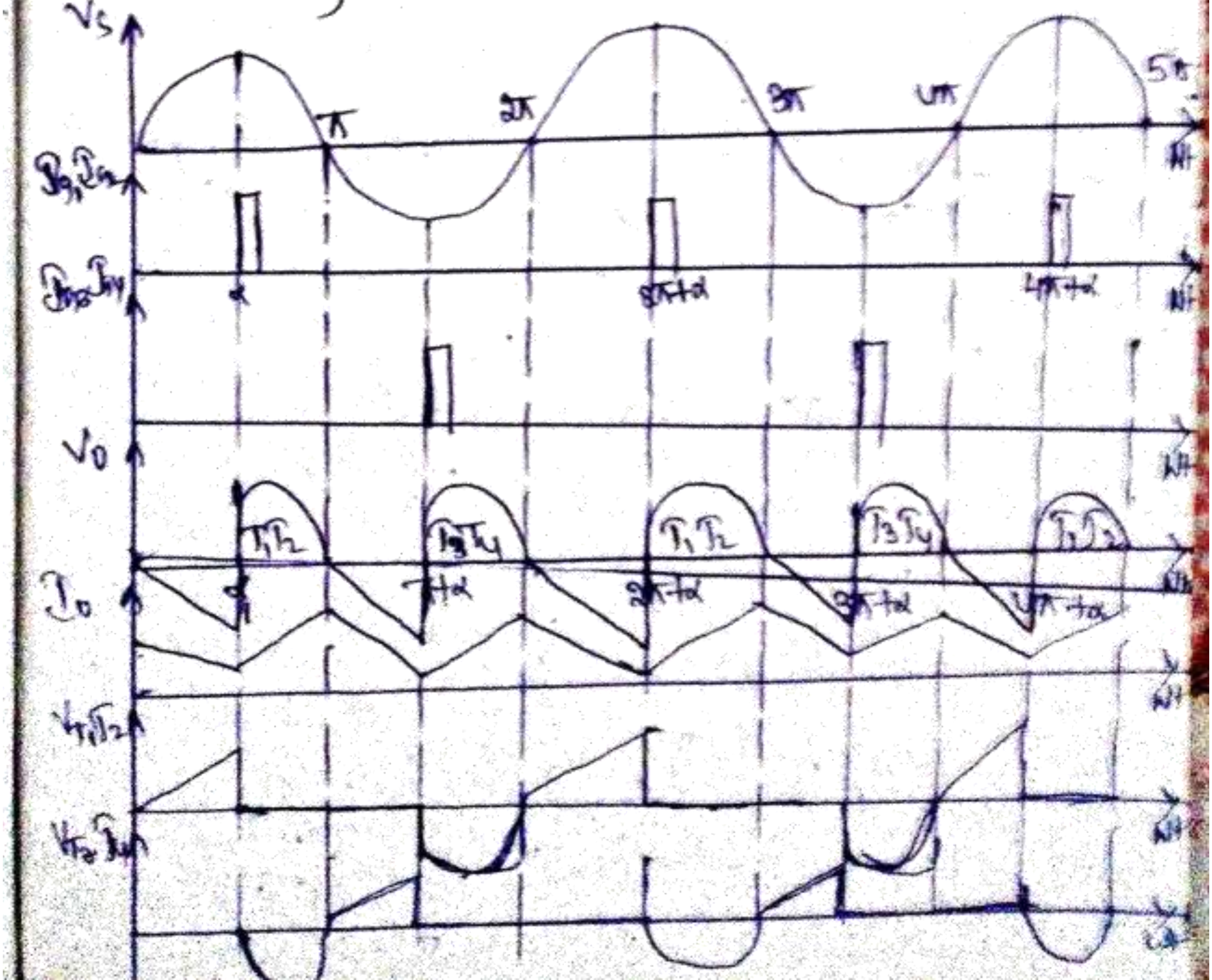
Continuous Mode



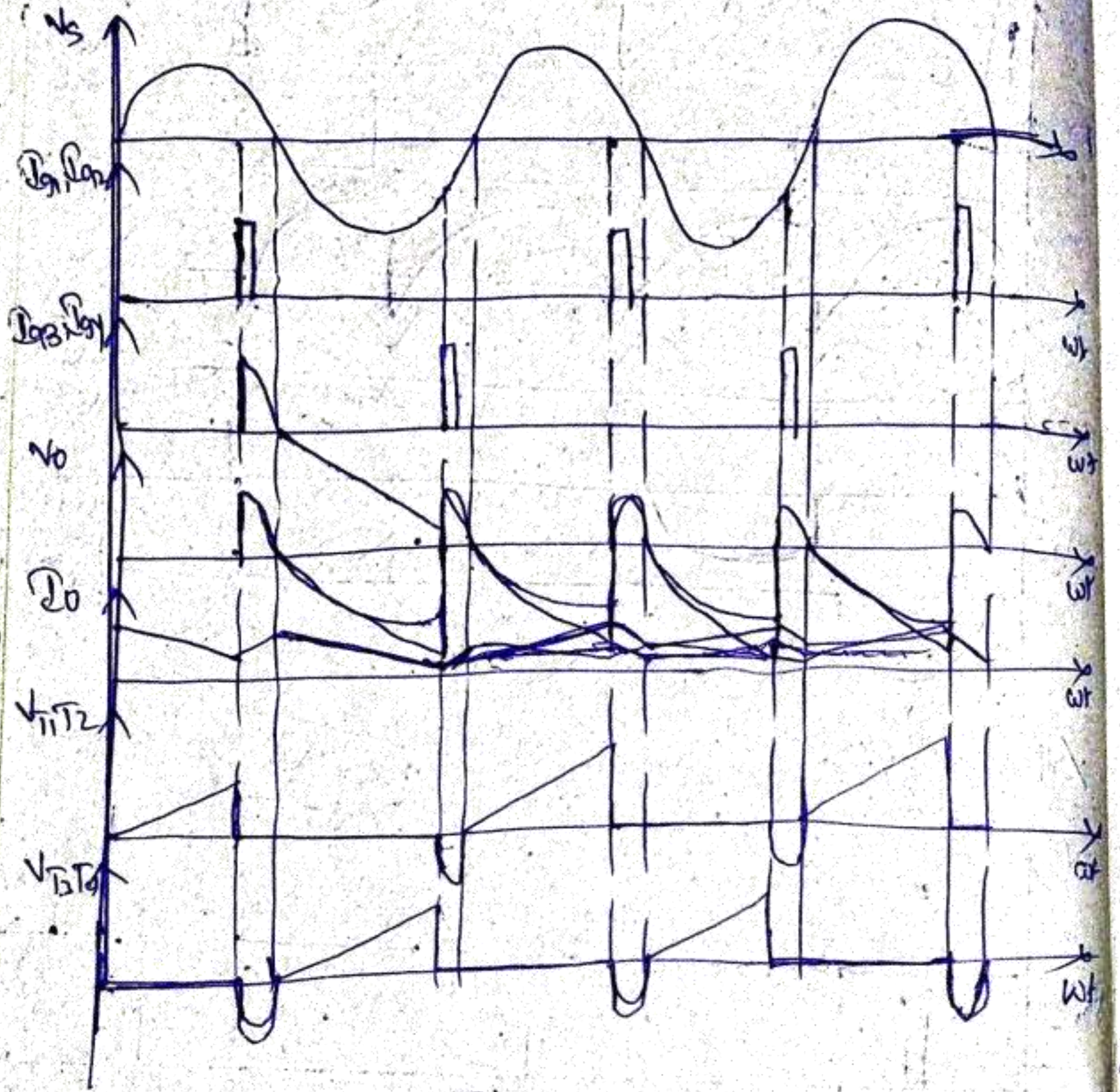
Same



At firing angle 90° $\boxed{\alpha = \pi/2}$



At firing angle $\alpha = 150^\circ$



$$V_0 = \frac{2}{2\pi}\int_{\alpha}^{\pi+\alpha} V_m \sin\omega t \, d\omega t$$

$$\boxed{V_0 = \frac{2V_m}{\pi}\left[\cos\alpha\right]}$$

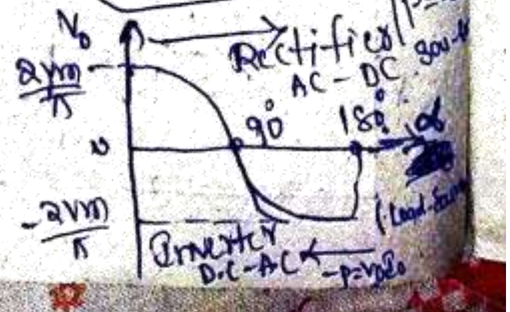
$$\boxed{I_0 = V_0 / R}$$

$$\rightarrow \boxed{I_0 = \frac{2V_m}{\pi R}\cdot \cos\alpha}$$

$\Rightarrow$ $V_0 = \frac{2V_m}{\pi} \Rightarrow \alpha = 0$

$V_0 = 0 \Rightarrow \alpha = 90^\circ$

$V_0 = \frac{-2V_m}{\pi} \Rightarrow \alpha = 180^\circ$



$$\boxed{V_{o\,rms} = \frac{V_m}{\sqrt{2}\,\pi}\left[\pi + \tfrac{1}{2}\sin\omega t\right]^{1/2}}$$

$$\Rightarrow \boxed{I_{o\,rms} = \frac{V_{o\,rms}}{R} = \frac{V_m}{\sqrt{2}\pi R}\left[\pi + \tfrac{1}{2}\sin\omega t\right]^{1/2}}$$

* $0 - 90^\circ \rightarrow$ Rectifier function

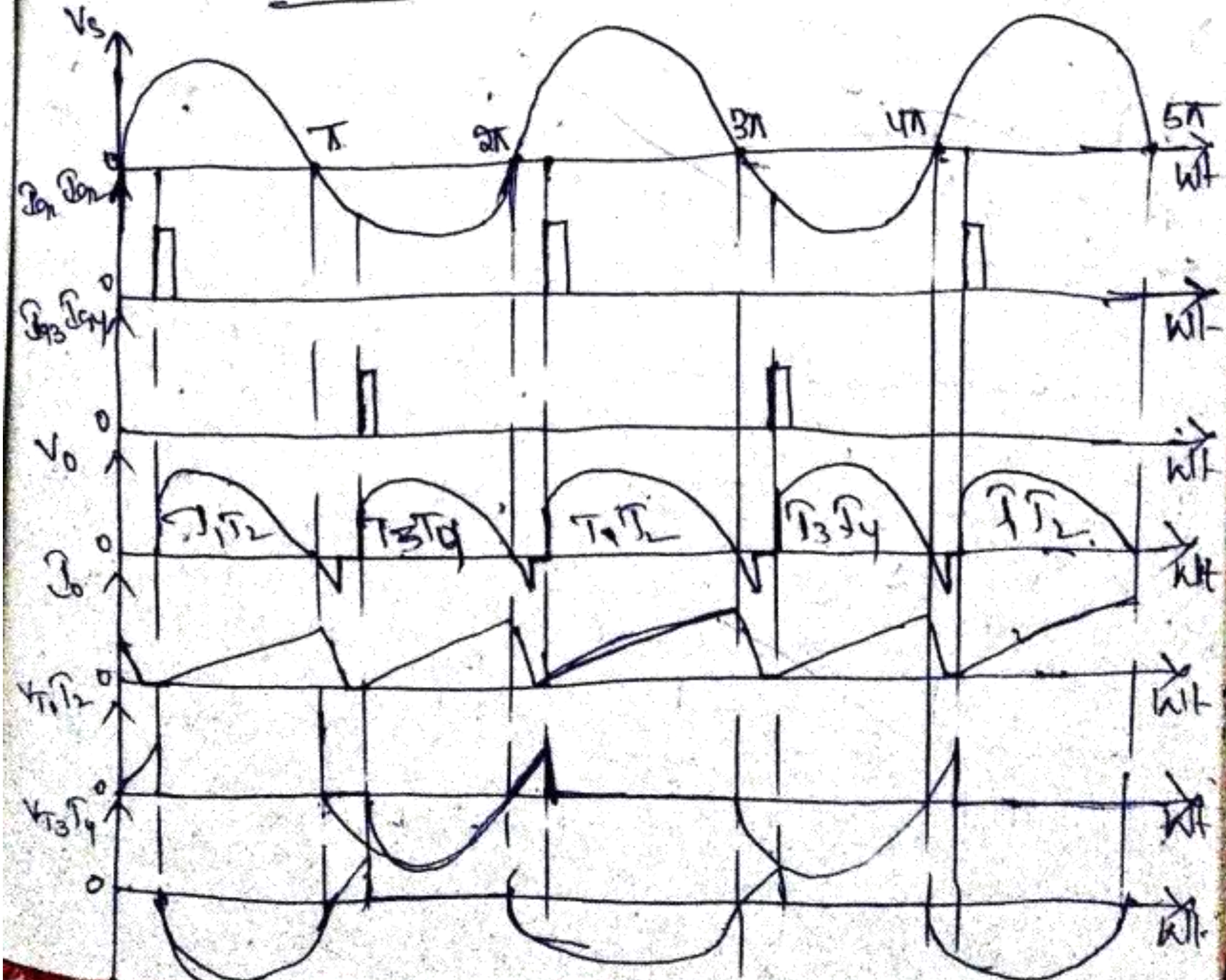
$90^\circ - 180^\circ \rightarrow$ Inverter function

01/08/19. Thurs

* 1-ϕ fully load Converter With R-L Load:-

D.C.M :-

Same diagram

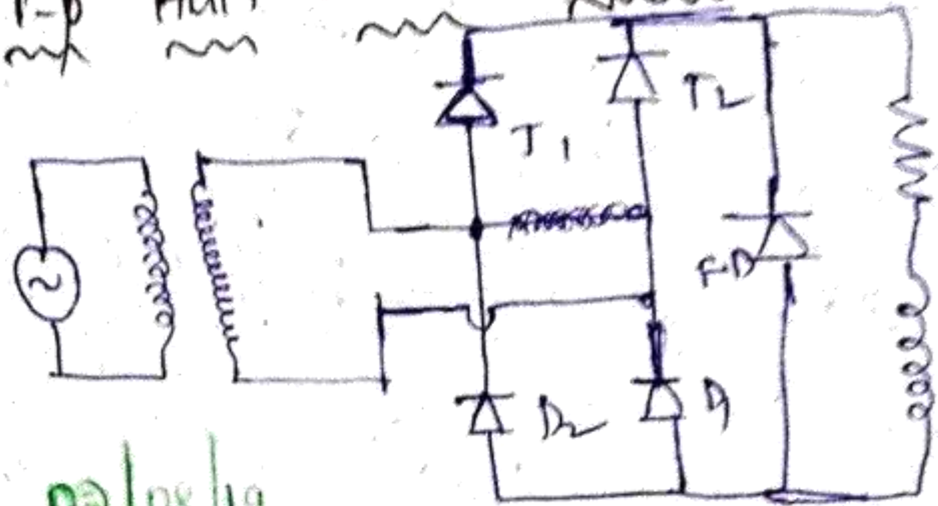


$$V_0 = \frac{2}{2\pi}\int_{\alpha}^{\beta} V_m \sin\omega t \, d\omega t$$

$$\boxed{V_0 = \frac{V_m}{\pi}\left[\cos\alpha - \cos\beta\right]}.$$

Semi Conductor

* 1-ϕ Half Controlled Converter :-



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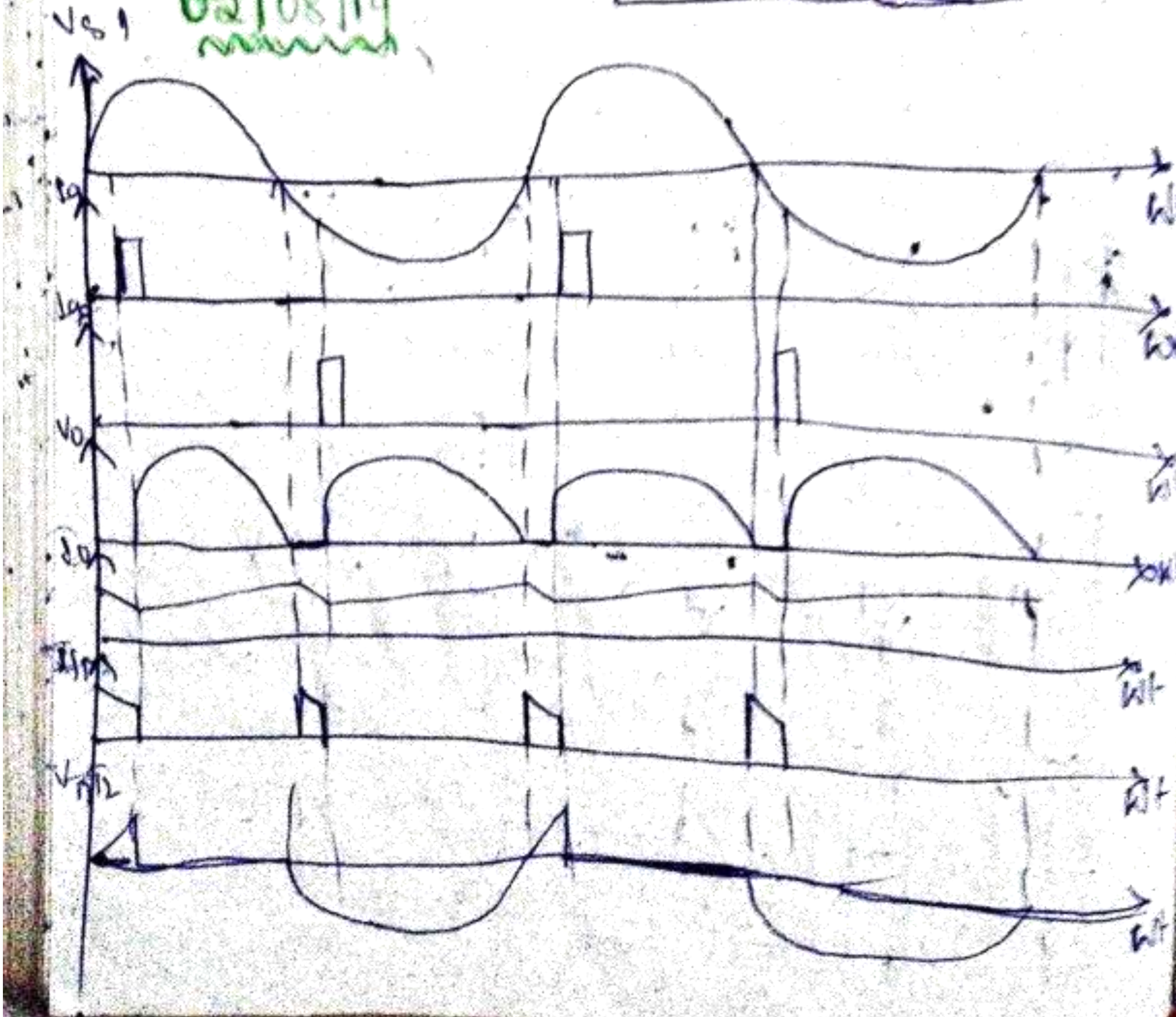
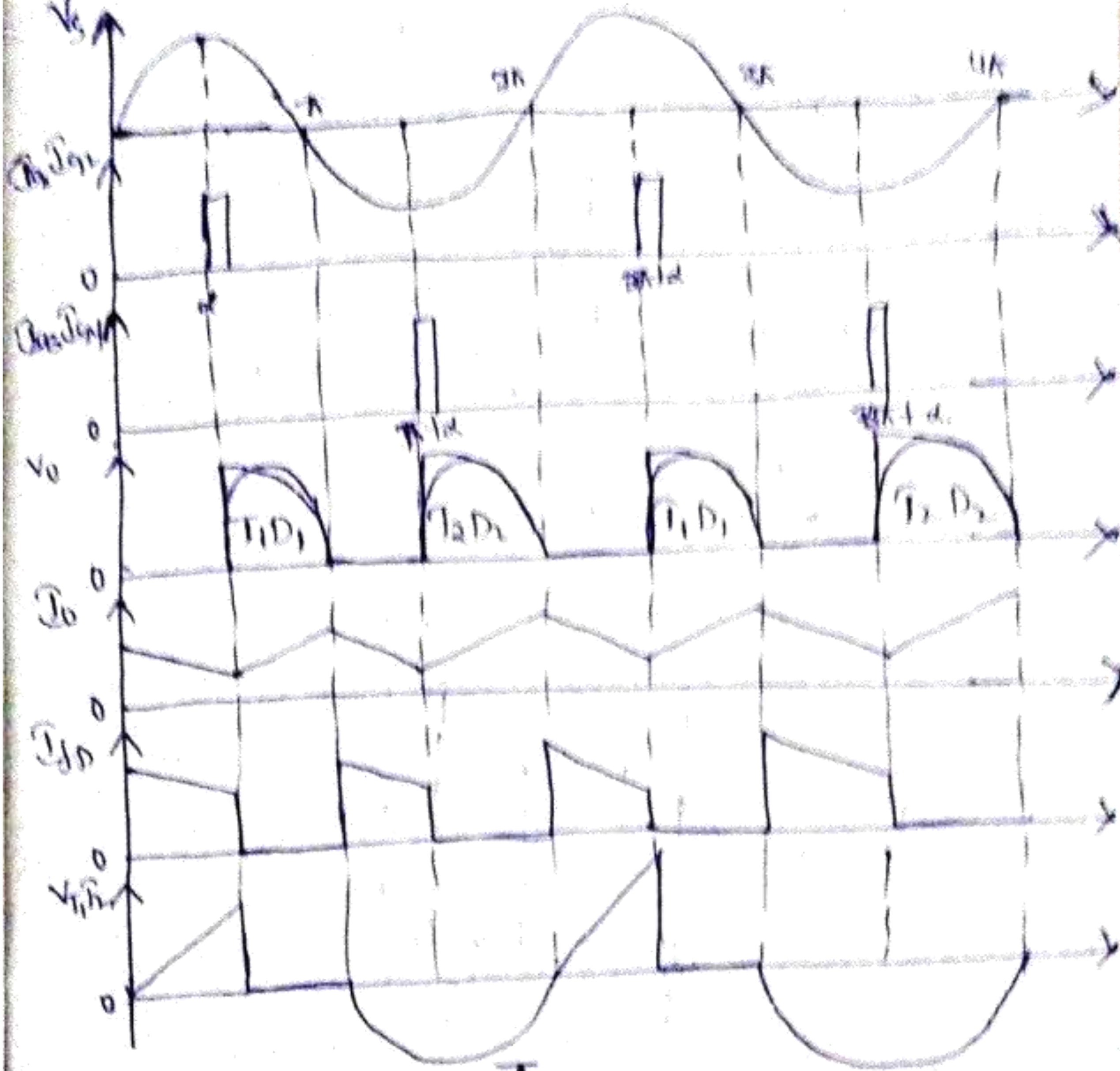


$\alpha = 90°$



$$\Rightarrow V_0 = \frac{2}{2\pi} \int_{\alpha}^{\pi} V_m \sin\omega t \, dt$$

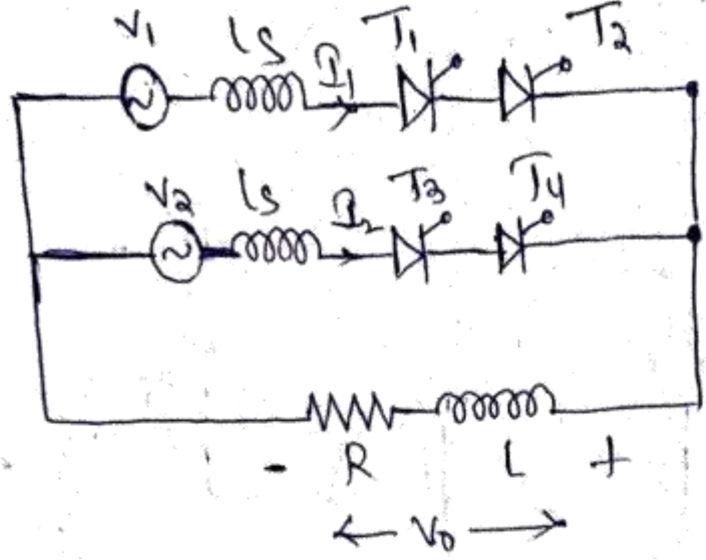
$$\boxed{V_0 = \frac{V_m}{\pi} [1 + \cos\alpha]}$$

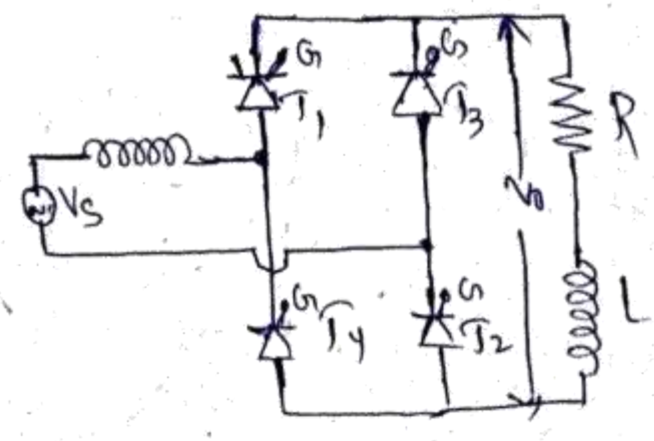
$$\Rightarrow \boxed{I_0 = V_0/R \rightarrow \frac{V_m}{R\pi} (1 + \cos\alpha)}$$

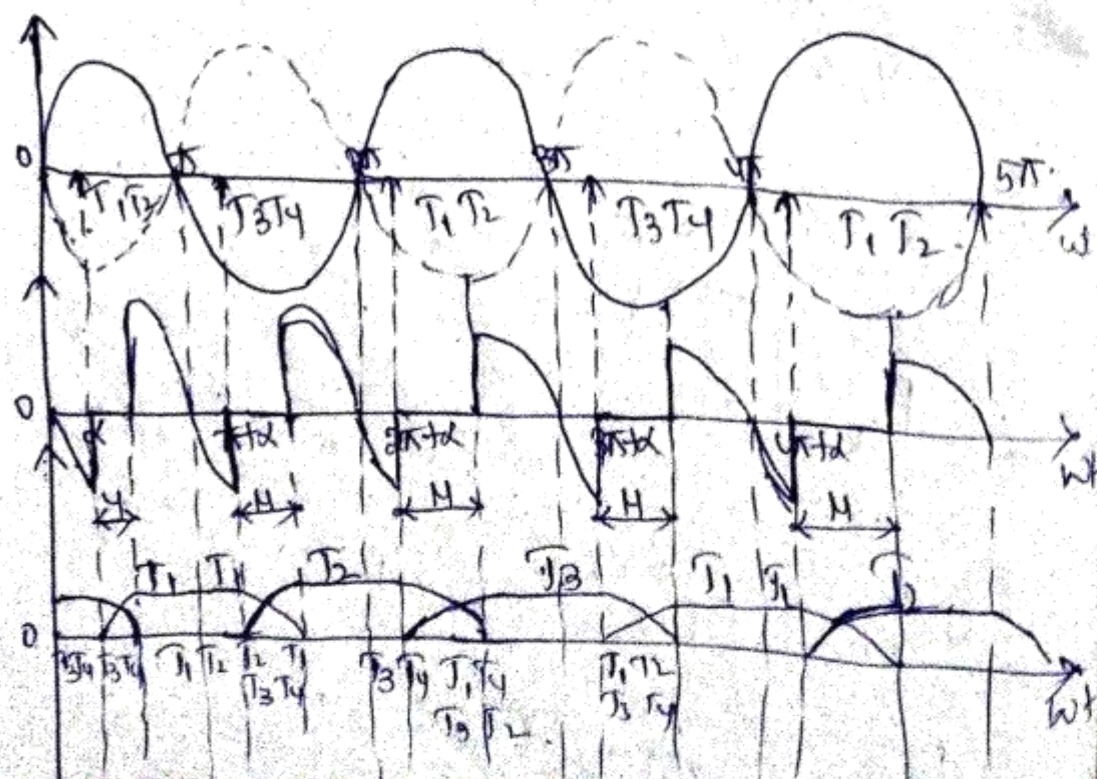
$$V_{orms} = \frac{V_m}{\sqrt{2\pi}} \left[(\pi - \alpha) + \frac{1}{2} \sin\omega t\right]^{1/2}$$

$$I_{orms} = \frac{V_m}{\sqrt{2}R\pi} \left[(\pi - \alpha) + \frac{1}{2} \sin\omega t\right]^{1/2}$$

* Effect of Source of impedance ON 1-φ full Converters With RL load :-







During the overlap angle KVL for the loop abcda.

$$V_1 - L_s\frac{di_1}{dt} = V_2 - L_s\frac{di_2}{dt}.$$

$$V_1 - V_2 = L_s\left(\frac{di_1}{dt} - \frac{di_2}{dt}\right).$$

$\therefore$ $V_1 = V_m \sin \omega t$, $V_2 = -V_m \sin \omega t$.

$$L_s\left(\frac{di_1}{dt} - \frac{di_2}{dt}\right) = 2V_m \sin \omega t \longrightarrow (1)$$

As the load current is assumed constant throughout. $I_1 + I_2 = I_0$

Differentiation w.r.t "t".

$$\frac{di_1}{dt} + \frac{di_2}{dt} = 0 \longrightarrow (2)$$

Adding Eqn (1) & (2) we get.

$$\cancel{2V_m \sin \omega t} \cdot \frac{di_1}{dt} = \frac{V_m}{L_s}\sin \omega t \longrightarrow (3)$$

→ Load current 'I_1' through thyristor 'T_1' & 'T_2' rises 0 to $I_1 = I_0$. During overlap angle.

→ Now, At $\omega t = \alpha$, $i_1 = 0$ and at $\omega t = (\alpha + \mu)$,
$i_1 = I_0$.

from Eqn (3)

$$\int_0^{i_1} di_1 = \frac{V_m}{L}\int_{\alpha/\omega}^{\alpha+\mu/\omega} \sin \omega t \, d\omega t$$

$$I_0 = \frac{V_m}{\omega L_s}\left[\cos\alpha - \cos(\alpha+\mu)\right] \rightarrow (4)$$

$$\Rightarrow \cos(\alpha+\mu) = \cos\alpha - \frac{\omega L_s}{V_m} \cdot I_0 \rightarrow (5)$$

* The o/p voltage V_0 is "0 from α to $\alpha+\mu$".

* Thus the average o/p voltage $V_{0\alpha}$ is given by

$$V_{0\alpha} = \frac{V_m}{\pi}\int_{\alpha+\mu}^{\pi+\alpha} \sin\omega t \, d\omega t$$

$$V_{0\alpha} = \frac{V_m}{\pi}\left[\cos(\alpha+\mu) - \cos(\pi+\alpha)\right]$$

$$\boxed{V_{0\alpha} = \frac{V_m}{\pi}\left[\cos\alpha + \cos(\alpha+\mu)\right]} \rightarrow (6)$$

The average value of o/p voltage at No load.

$$\boxed{V_0 = \frac{2V_m}{\pi}\cos\alpha}$$

Maximum Mean o/p voltage.

$$\boxed{V_{0_{m}} = \frac{2V_m}{\pi}} \text{ When } \alpha = 0$$

Eqn (6) Can be Expressed as.

$$V_{0\alpha} = \frac{\text{Max. Mean o/p voltage}}{2}\left[\cos\alpha + \cos(\alpha+\mu)\right]$$

$$V_{or} = \frac{V_m}{2}\left[\cos\alpha + \cos(\alpha+\mu)\right] \rightarrow (7)$$

→ Substitute Eqn (5) in Eqn (6)

$$V_{or} = \frac{2V_m}{\pi}\cos\alpha - \frac{\omega L_s}{\pi}\cdot I_0$$

$$= \frac{2V_m}{\pi}\cos\alpha - 2fL_s \cdot I_0 \longrightarrow (8)$$

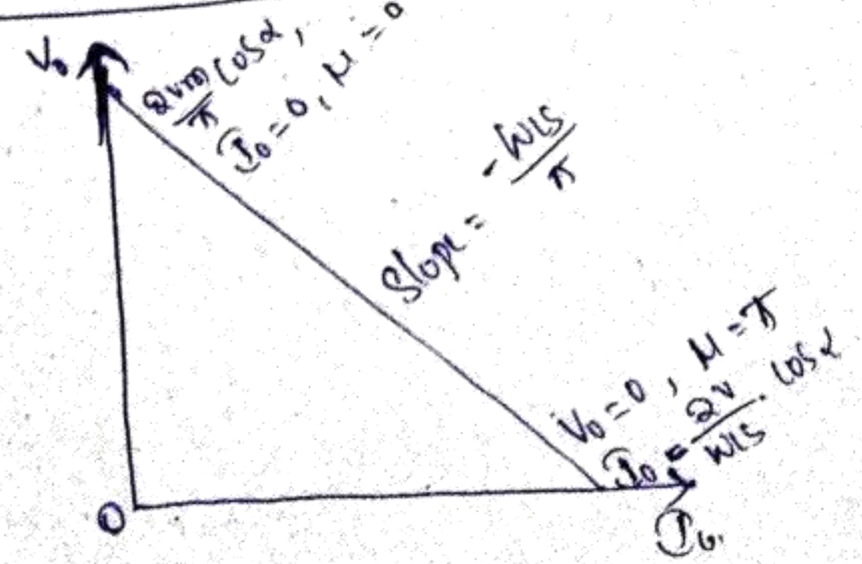
from Eqn-(4) ⇒

$$\cos\alpha = \frac{\omega L_s}{V_m}\cdot I_0 + \cos(\alpha+\mu) \longrightarrow (9)$$

from Eqn (9) in (6)

$$\cancel{V_{or} = \frac{2V_m}{\pi}\left\{\frac{\omega L_s}{V_m}\cdot I_0 + \cos(\alpha+\mu) + \cos(\alpha+\right.}$$

$$\boxed{V_{or} = \frac{2V_m}{\pi}\cos(\alpha+\mu) + \frac{\omega L_s}{\pi}\cdot I_0} \rightarrow (10)$$



Problems

Q1 :- 230V, 50Hz, 1 Pulse SCR Controlled Converted is triggered act as firinge angle 40°, and the load current and st neeligst. at an angle of ~~200°~~ 210°. Find the circuit turn off the time, calculate the average voltage, average load current for R=5Ω, L=2mH

Given data :-

$V_s = 230V$

$F = 50Hz$

$\alpha = 40°$

$\beta = 210°$

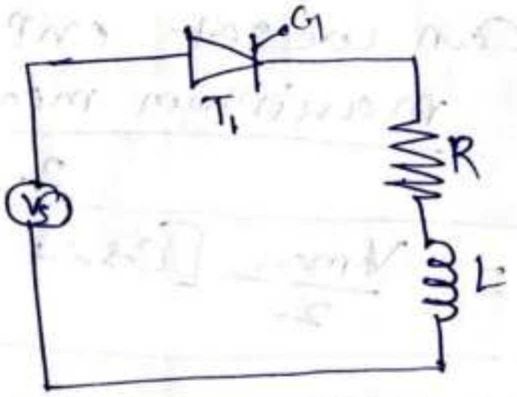
$R = 5\Omega$

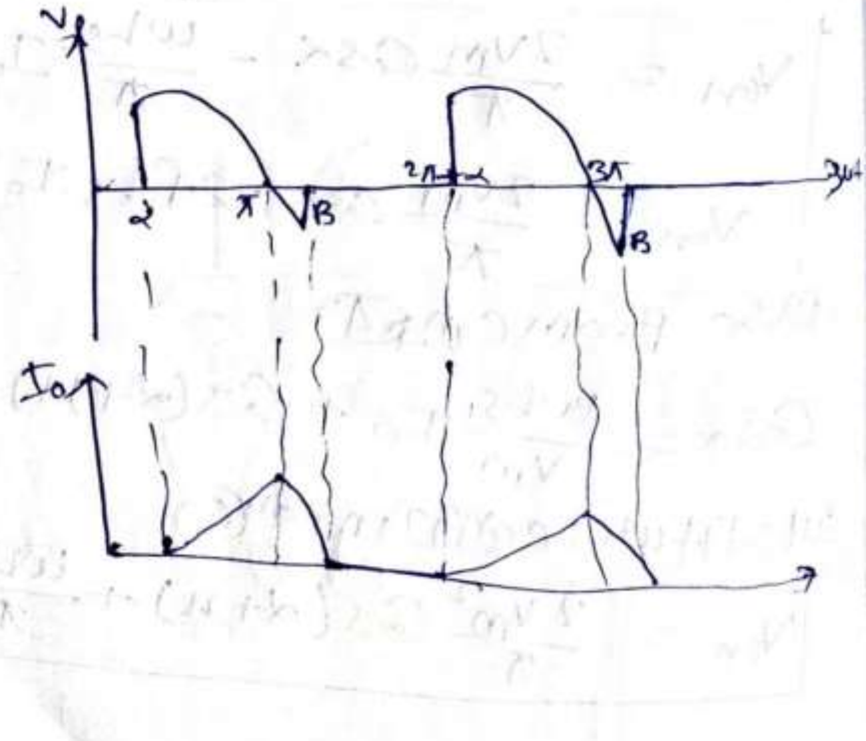
$L = 2mH$

$t_c = ?$

$V_0 = ?$

$I_0 = ?$





From this wave waveform

$\omega t = 2\pi - \beta$

$t_c = \frac{2\pi - \beta}{\omega}$

(i) $t_c = \frac{360 - 210}{2\pi \times 50}$

$= 8.33 \text{ msec}$

ii) $V_0 = \frac{V_m}{2\pi}(\cos\alpha - \cos\beta)$

$V_0 = \frac{\sqrt{2} \times V_s}{2\pi}(\cos 40 - \cos(210)) = \frac{\sqrt{2} \times 230}{2\pi}(\cos 40 - \cos(210))$

$V_0 = 84.48V$

(ii) Average load current

$I_o = \frac{V_o}{R} = \frac{84.48}{5} = 16.89A$

Q) A 1-ϕ 230V, 1KW heater is connected across 230V 1-ϕ supply, 50Hz, 2 An SCR Through an SCR, 4000 firing angle delay of 45° and 90°. Calculate of Power observe in the B.

Given data:-

heater:-

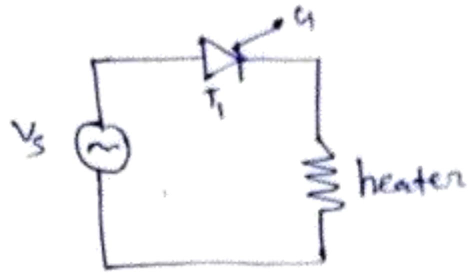
$V = 230V$

$P = 1KW$

$\alpha = 45°$

$= 90°$

$F = 50Hz$



Power observed by the heater

= Rms output voltage x Rms output current

$P_o = V_{rms} \times I_{rms}$ $\left(I_{rms} = \frac{V_{Rms}}{R} \right)$

$P = \frac{(V_{rms})^2}{R}$

Heater resistance $(R) = \frac{V^2}{P} = \frac{(230)^2}{1000}$

$= 52.9\Omega$

i) $V_{oRms} = \frac{\sqrt{2} \times V_s}{2\sqrt{\pi}} \left[(\pi - \alpha) + \frac{1}{2} \sin 2\alpha \right]^{1/2}$

Case-I :-

$= \frac{\sqrt{2} \times 230}{2\sqrt{\pi}} \left[(\pi - 45°) + \frac{1}{2} \sin 2(45°) \right]^{1/2} \times \frac{\pi}{180}$

$= 155.07V$

Heater resistance $(R) = \frac{V_{orm}^2}{P} = \frac{(155.07)^2}{1000} = 24.04V$

Case-II :-

$= \frac{\sqrt{2} \times 230}{2\sqrt{\pi}} \left[(\pi - \pi/2) + \frac{1}{2} \sin(2 \times 90) \right]^{1/2}$

$= 115V$

Heater resistance $(R) = \frac{V^2}{P} = \frac{115^2}{1000} = 24.025V$