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* Power Devices & Circuit *

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* ASSIGNMENT 2 *

Q1) What do you mean by commutation of SCR? Explain its types.

Ans:- The process of turning off of a conducting SCR is known as "commutation"
The two types of commutation are:-
i) Natural commutation (AC source)
ii) Forced commutation (DC source)

1) Natural commutation:-
When the SCR is turned off, due to its forward current going below the holding current naturally it is said to be naturally ~~be~~ commutated.
The natural commutation usually takes place when AC supply is given as a input to the circuit.
~~In which~~

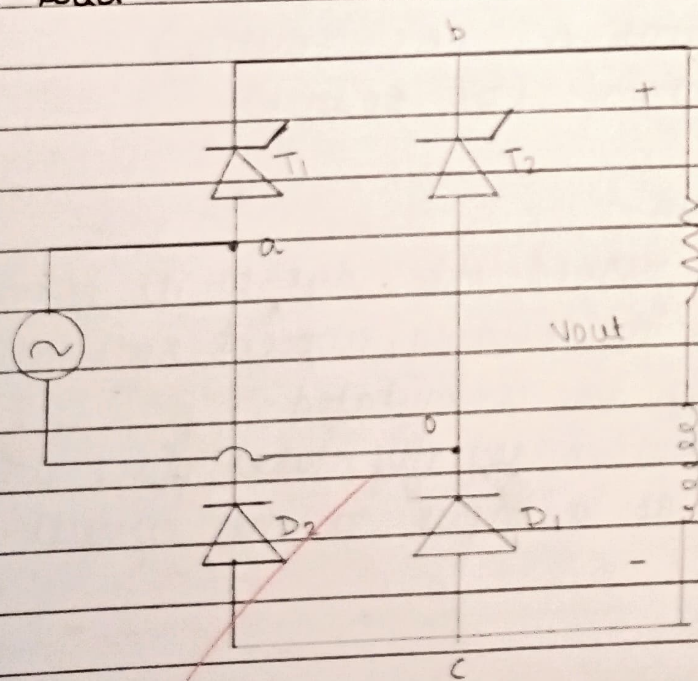
2) Forced commutation:-
When the SCR's operate on a pure DC input voltage, their forward current cannot be reduced below holding current naturally. Therefore the SCRs must be commutated "externally" using "commutation circuit". This external circuit will turn off the SCR's by means of either current commutation or voltage commutation. Such type of commutation is called as forced commutation.

Q2) What is meant by delayed angle.

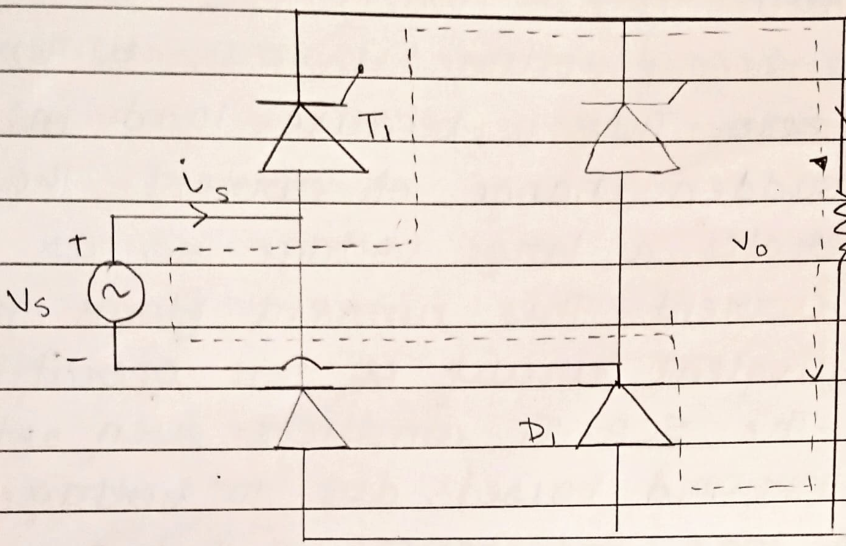
Ans :- The angle between the zero crossing of input voltage and the instant the thyristor is fired is known as delayed angle.

Q3) With the help of neat circuit diagram mode equivalent circuits and waveform of supply voltage, supply current, output voltage, output current. Explain the operation of a single phase half control bridge with RL load.

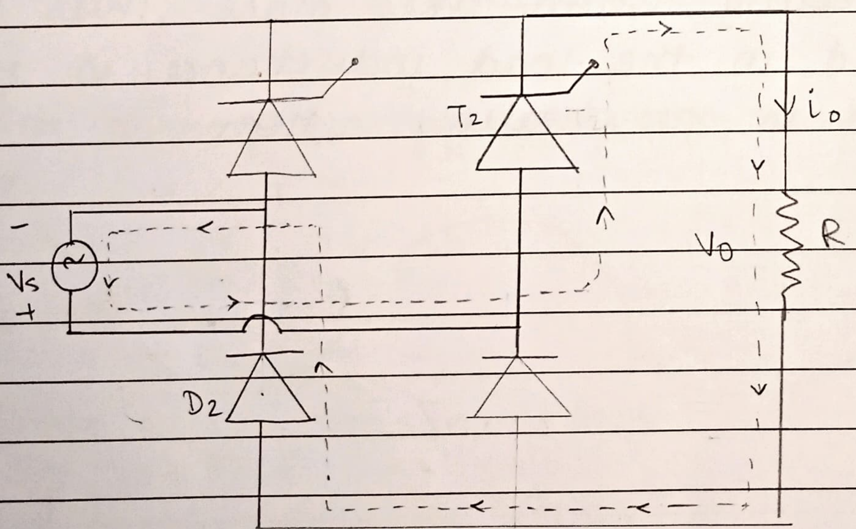
Ans :-



Conduction of T_1 & D_1 in positive half cycle.



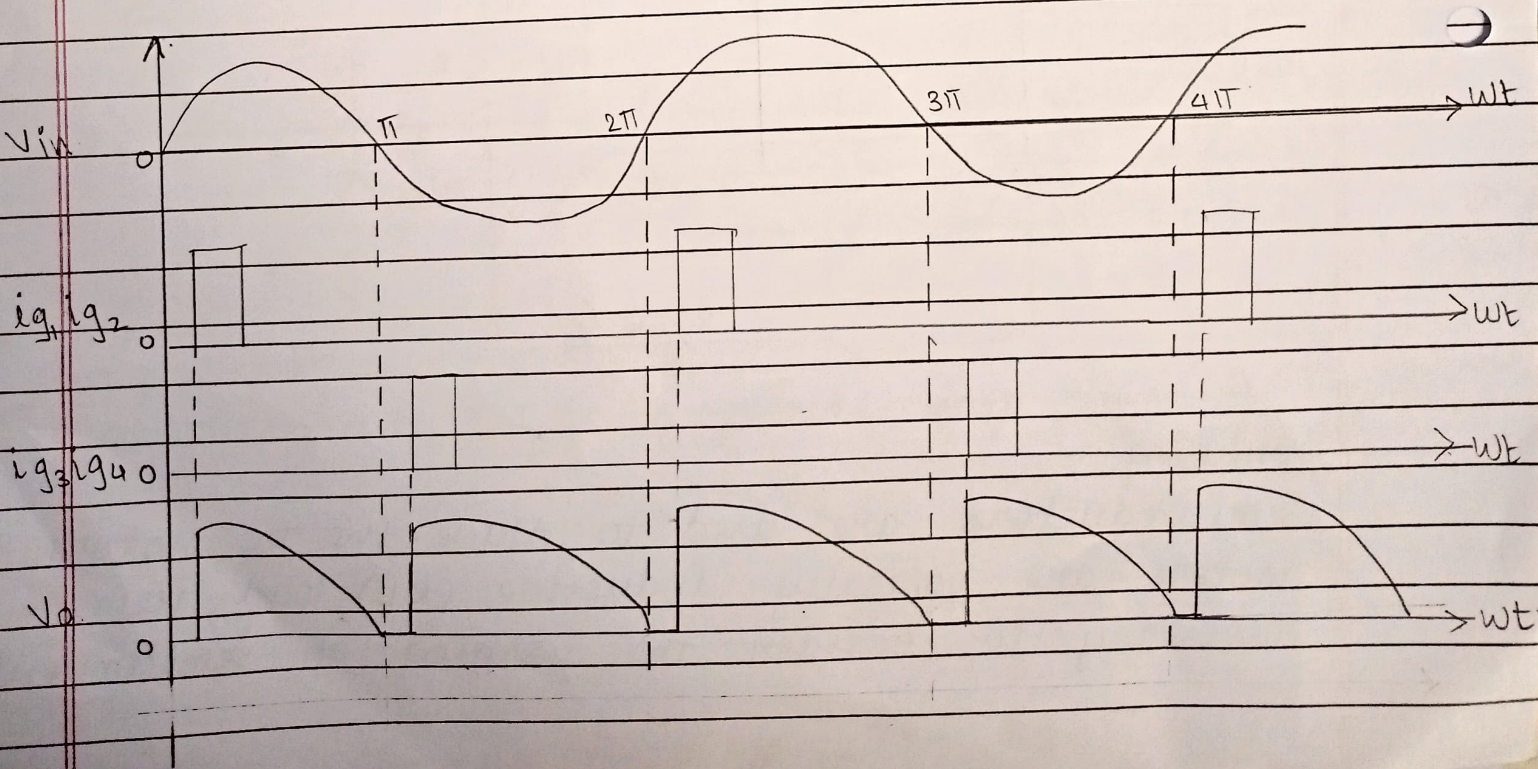
conduction of T_2 & D_2 in negative half cycle.



Working :-
semiconductors are used to drive the DC motors. These motors are basically inductive (RL) load. Hence it is necessary to consider the working of semiconvertors

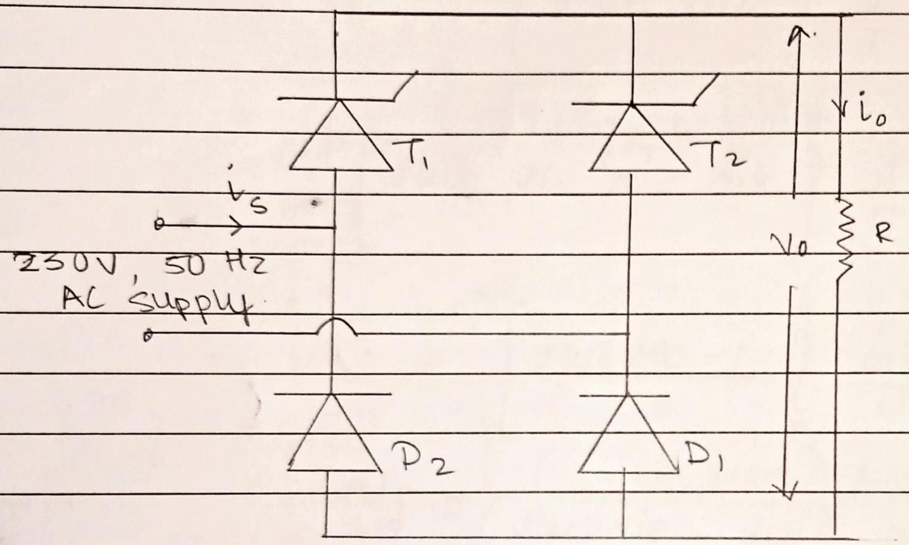
with RL load. also.
even though the supply voltage is zero, current doesn't go to zero. This is because load inductance opposes this sudden change of current. The load inductance generates a large voltage so as to maintain load current. This current flows through T_1 & D_2. The equivalent circuit of this operation is shown in fig. The SCR T_1 conducts even after π since it is forward baised due to voltage induced in the load inductance i.e $L\frac{di}{dt}$.

Diode D_2 is also forward biased due to this voltage. Hence current does not flow through supply i.e i_s when free wheeling action takes place. Thus the energy stored in the load inductance is fedback to load itself in freewheeling action.



Q3) Draw the circuit diagram of single phase semi-converter for R load. Explain the operation with the help of voltage and current waveform & derive its expression.

Ans :-



for average voltage for half wave rectifier.

$$V_o = \frac{1}{T}\int_0^T V_{in}\, dt.$$

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

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

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

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

The expression for RMS output voltage (V_{orms}) is

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

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

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

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

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

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

Average Thyristors current

$$I_{CTH} = \frac{V_{Ldc}}{R}$$

$$= \frac{1}{T}\int_0^T I_{in} \, d\omega t$$

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

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

$$\therefore I_{dcTH} = \frac{I_m}{2\pi}\left[1+\cos\alpha\right]$$

RMS value of current.

$$I_{LRMS} = \left[\frac{1}{T}\int_{0}^{T} I_{in}^{2}\, d\omega t\right]^{1/2}$$

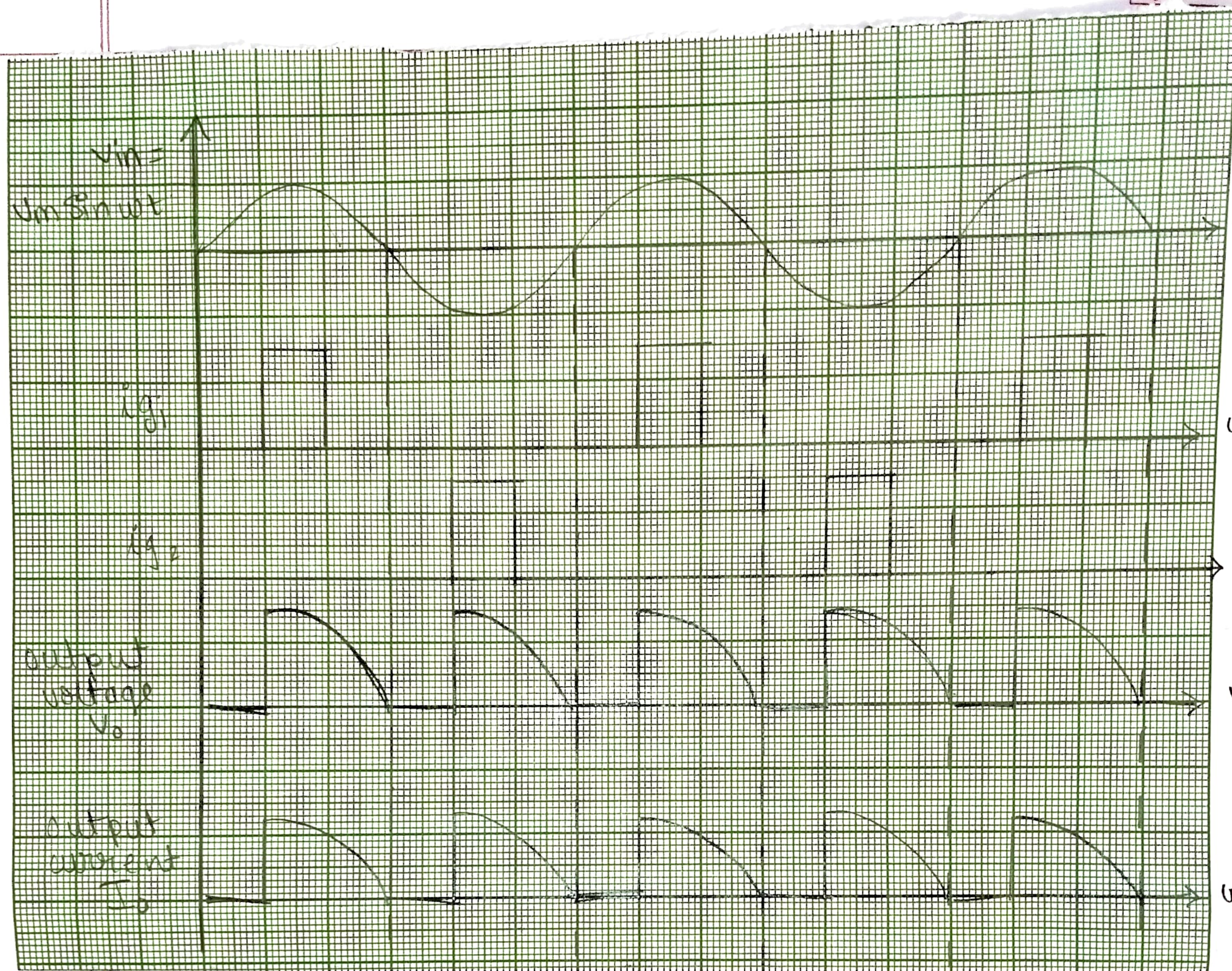
$$= \left[\frac{1}{2\pi}\int_{\alpha}^{\pi} I_{in}^{2}\sin^{2}\omega t\, d\omega t\right]^{1/2}$$

$$= \left[\frac{I_m^2}{4\pi}\int_{\alpha}^{\pi}\left(\frac{1-\cos 2\omega t}{2}\right) d\omega t\right]^{1/2}$$

$$= \left[\frac{I_m^2}{4\pi}\left[\omega t - \frac{\sin 2\omega t}{2}\right]_{\alpha}^{\pi}\right]^{1/2}$$

$$= \left[\frac{I_m^2}{4\pi}\left[\pi-\alpha - \frac{\sin 2\pi - \sin 2\alpha}{2}\right]\right]^{1/2}$$

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



5) A single phase semi converter is operated from 120V, 50 Hz AC supply. The load Resistance is 10 Ω. The average output is 25% of max possible average output voltage. Determine
1) firing angle
2) RMS & average o/p current
3) RMS & average Thyristor current.

→ $V_{RMS} = 120\,V$

$\therefore V_{RMS} = \frac{V_m}{\sqrt{2}}$ $\qquad \therefore V_m = \sqrt{2} \times 120$

a) V_{odc} = max voltage $= \frac{2V_m}{\pi}$

$= \frac{2 \times \sqrt{2} \times 120}{\pi}$

$\therefore V_{odc} = 108.096$ V.

Avg o/p voltage = 25% ~~of~~ V_{odc}

$= \frac{25}{100} \times 108.096$

$= \cancel{27 V}\ 27.024$ V

$V_o = \frac{V_m}{\pi}(1 + \cos\alpha)$

$27.024 = \frac{\sqrt{2} \times 120}{\pi}(1 + \cos\alpha)$

$\frac{27.024 \times 3.14}{\sqrt{2} \times 120} = (1 + \cos\alpha)$

$(1 + \cos\alpha) = \cancel{0.500}\ 0.5$

$\therefore \cos\alpha = 0.500 - 1$

$\cos\alpha = -0.499$

$\therefore \alpha = 119.93 = 120°$

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

$= \left[\frac{(\sqrt{2} \times 120)^2}{2\pi}\left(\pi - 120° + \frac{\sin(2 \times 120)}{2}\right)\right]^{1/2}$

$\therefore V_{orms} = 53$ volts.

$\therefore$ rms load current $= \dfrac{V_{orms}}{R}$

$= \dfrac{53}{10}$

$\therefore I_{orms} = 5.3$ Ampere.

Average load current $= \dfrac{V_{Ldc}}{R}$

$= \dfrac{27}{10}$

$\therefore I_{Ldc} = 2.7$ Amp

c) $I_m = \dfrac{V_m}{R} = \dfrac{\sqrt{2} \times 120}{R} = \dfrac{\sqrt{2} \times 12\cancel{0}}{1\cancel{0}} = 16.97$ Amp

Average Thyristor current,

$I_{dcTH} = \dfrac{I_m}{2\pi}[1 + \cos(\alpha)]$

$= \dfrac{16.97}{2\pi}[1 + \cos(120)]$

$= 1.35$ A.

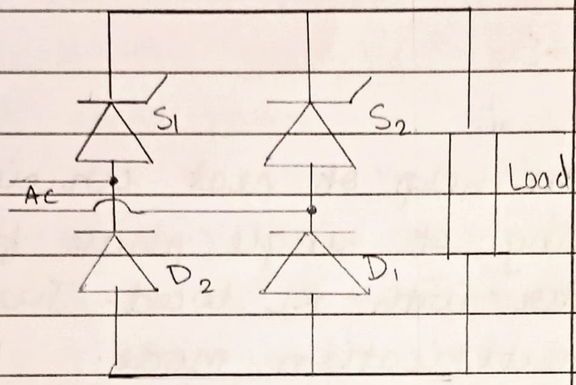
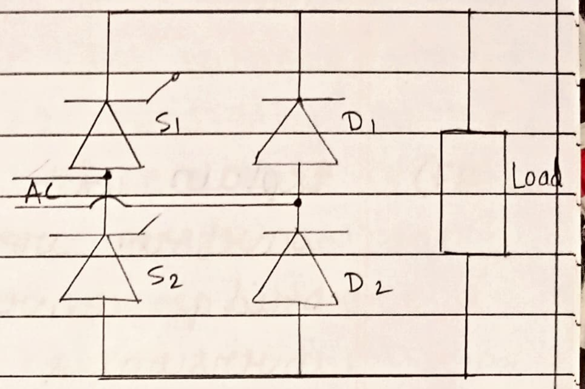
RMS value of current.

$I_{LRMS} = \left[\dfrac{I_m^2}{4\pi}\left(\pi - \alpha + \dfrac{\sin 2\alpha}{2}\right)\right]^{1/2}$

$= \left[\dfrac{16.97^2}{4\pi}\left(3.14 - 120 + \dfrac{\sin 2 \times 120}{2}\right)\right]^{1/2}$

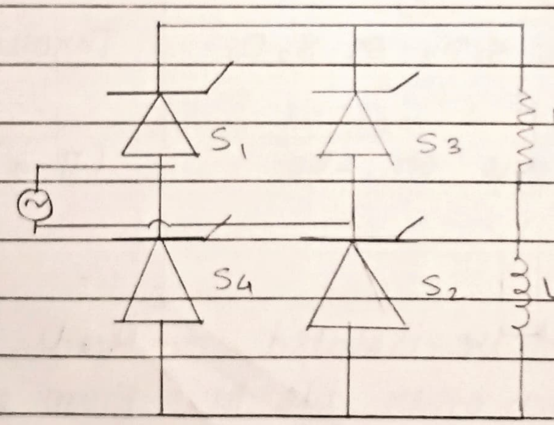
= 3.79 Ampere

Q6) compare symmetrical and asymmetrical configuration.

SR No	Parameters	Symmetrical configuration	Asymmetrical configuration.
1.	configuration		
2.	Freewheeling	Through S_1D_2 or S_2D_1	Through D_1D_2
3.	conduction angle of SCRs	π radians or 180°	$(\pi-\alpha)$ radians.
4.	Triggering pulses for the two SCR's	Need not be isolated from each other due to the common cathode connection.	Needs to be isolated from each other ~~due to~~ as the cathodes are at different potentials.
5.	Average output voltage	$V_{Ldc} = \frac{V_m}{\pi}(1+\cos\alpha)$	$V_{Ldc} = \frac{V_m}{\pi}(1+\cos\alpha)$
6.	Quadrant of operation	first	first.

7. Freewheeling action	Inherent	Inherent.
8. External freewheeling diode	Not required	Not required.

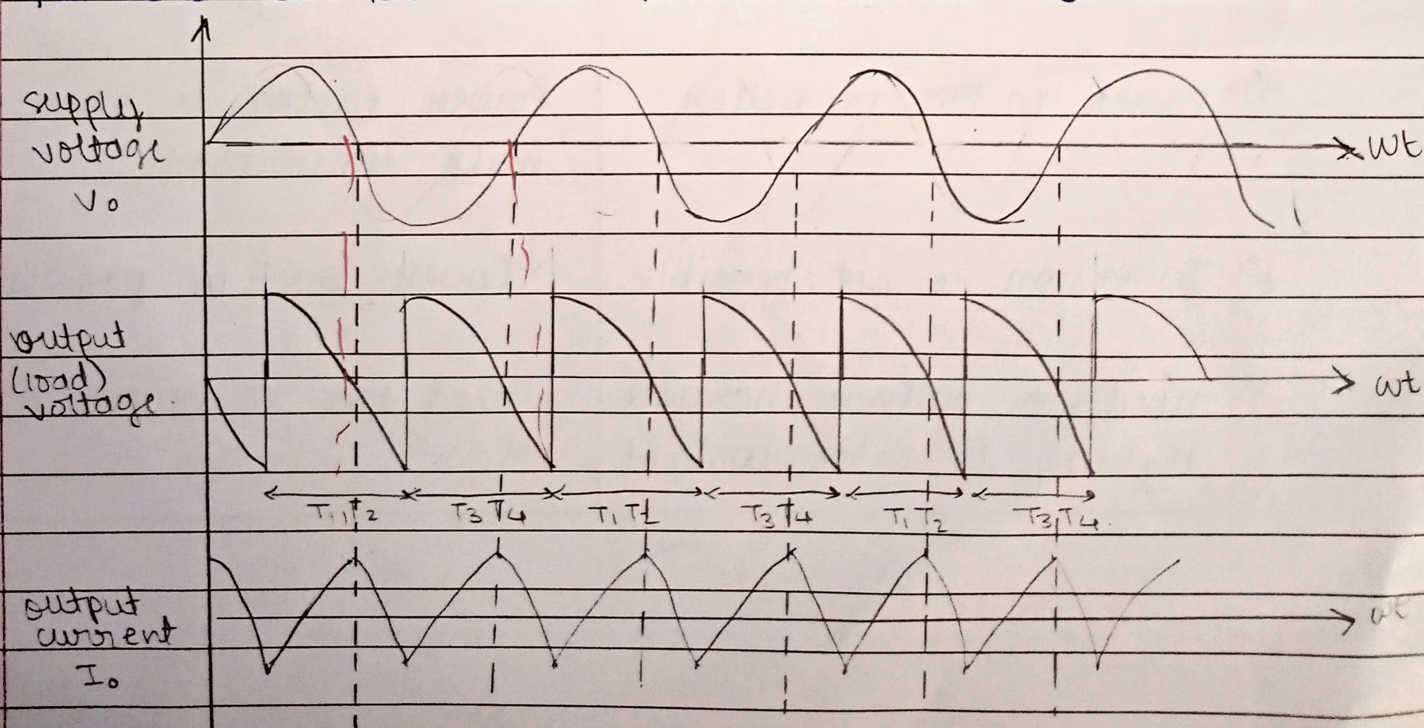
Q7) Explain with the help of neat circuit diagram, waveform working of single phase fully controlled bridge converter with RL load. Justify what is inversion & rectification mode.



The inductive load means resistance & inductance in the load. Such loads are DC motors. Because of RL load current shape is changed.
T_1 & T_2 are conducting from α to π. The nature of load current depends upon values of R & L in the inductive load. Beause of inductawnce, i_o keeps on increasing & becomes maximum at π. At π, the supply

voltage reverses but SCR T_1 & T_2 does not turn off. This is because, the load inductance does not allow the current to go to zero instantly. The load inductance generates a large voltage, $L\frac{di}{dt}$.

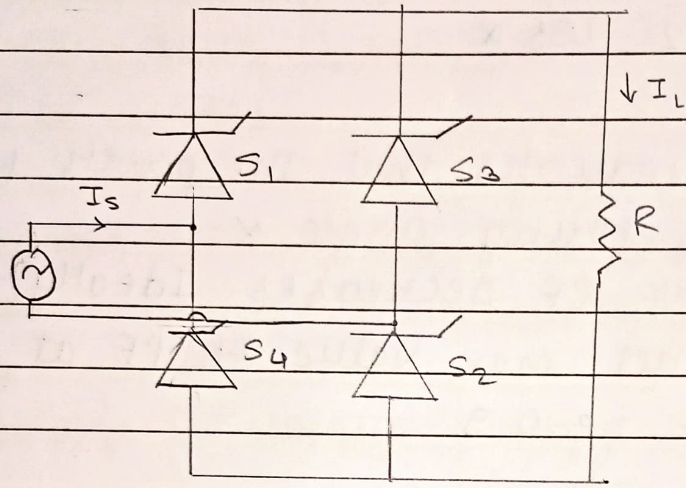
This voltage forward biases T_1 & T_2. The load current flows against the supply voltage. The energy stored in the load inductance is supplied partially to the main supply & to the load itself. Hence this is also called as feedback operation. The output voltage is negative from π to $\pi+\alpha$ since supply voltage is negative. But the load current keeps on reducing. At $\pi+\alpha$, SCRs T_3 & T_4 are triggered. The load current start increasing. The load current remains continuous in the load. The similar operation repeats. The ripple in the load current reduces as the load inductance is increased.



Q9) compare full converter & semi converter.

Half controlled convertor	Fully controlled convertor.
1) This consists of half number of SCRS & half number of diodes	This consists of all the SCRS as controlled devices
2) This operates in only one quadrant	This can operate in two quadrants
3) output voltage is always positive.	Output voltage can be negative in case of inductive loads.
4) Inherent freewheeling action is present.	External freewheeling diode is to be connected for free wheeling.
5) Power factor is better	Power factor is poor than half convertor.
6) Inversion is not possible	Inversion is possible.
7) Used for battery chargers, lighting & heater control.	Used for DC motor drives.

Q8) Draw the circuit diagram of single phase fully controlled converter for R load. Explain the operati[on] with the help of voltage & current waveform & derive its experssion.



1) In the positive half cycle of the input ac mains voltage the SCR_1 & SCR_2 are forward biased & hence can be turned on at the desired value of firing angle α.
2) As SCR_1 & SCR_2 are turned on at α the AC mains get connected across the load.
3) The load voltage is thus equal to instantaneous supply voltage.
4) At π, the supply voltage goes to zero. The load current also becomes zero & conducting SCR_1 & SCR_2 are turned off due to natural commutation.
5) All the SCRs remains off during the period π to $\pi + \alpha$. The load voltage & load current are zero during this mode of operation.
6) The ac input voltage becomes negative after π. This make[s] SCR_3 & SCR_4 forward biased.

7) ~~All~~ These SCRs are turned on at $(\pi+\alpha)$ in negative half cycle of input ac main voltage.

~~8) During this interval i.e from 0 to α all~~

Average load voltage,

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

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

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

Average load current,

$$I_{Ldc} = V_{LDC}/R$$

$$\therefore I_{Ldc} = \frac{V_m}{\pi R}\left[1+\cos\alpha\right]$$

RMS load voltage,

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

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

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

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

Average thyristor current.

$$I_{Th(avg)} = \frac{1}{2\pi} \int_{\alpha}^{\pi} I_m \sin \omega t \, d\omega t .$$

$$\therefore I_{th(avg)} = \frac{-I_m}{2\pi} \left[\cos \omega t \right]_{\alpha}^{\pi}$$

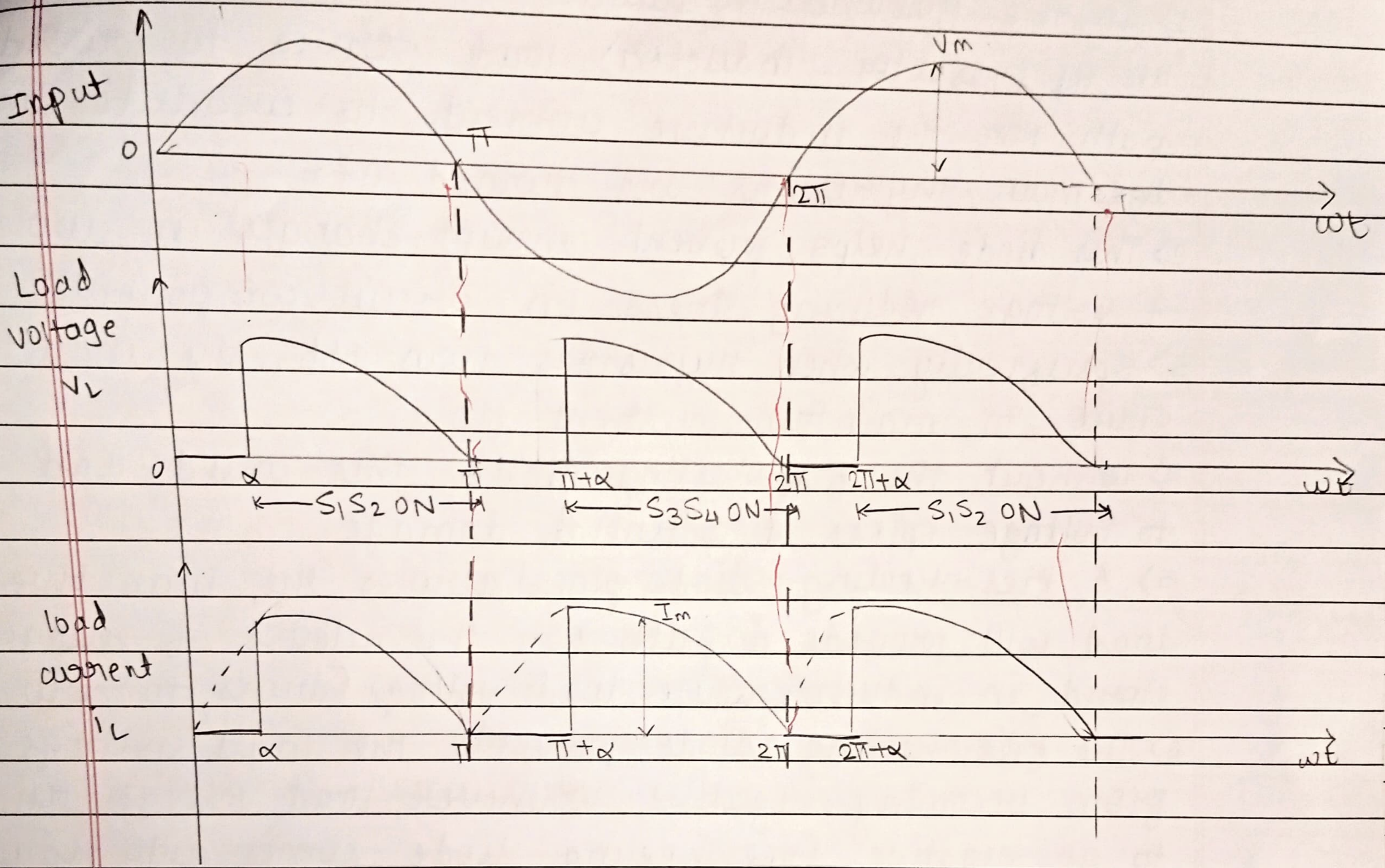
$$= \frac{-I_m}{2\pi} \left(\cos \pi - \cos \alpha \right]$$

$$= \frac{I_m}{2\pi} \left(1 + \cos \alpha \right)$$

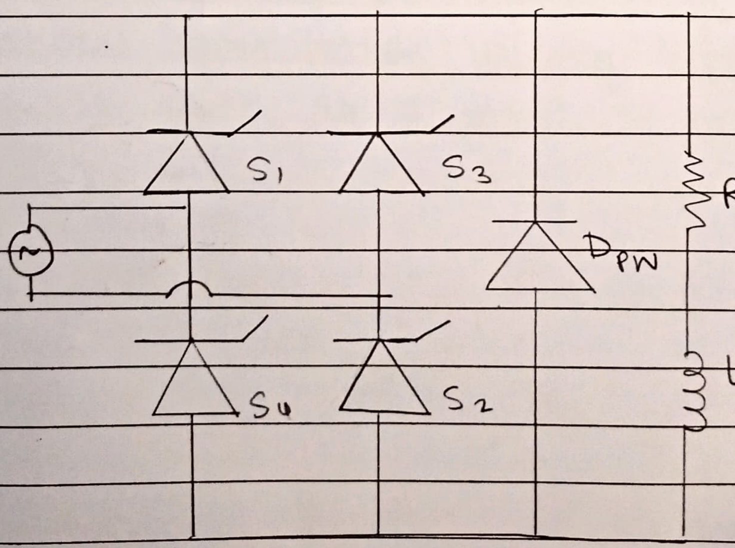
But $I_m = V_m / R$

$$\therefore I_{th(av)} = \frac{V_m}{2\pi R} \left(1 + \cos \alpha \right)$$

$$\therefore I_{th} = \frac{I_{Ldc}}{2}$$



Q10) what are effects of freewheeling diodes in full convertor for RL load.



1) In the freewheeling diode in a full converter for an RL (resistor - inductor) load serves to provide a path for the inductive current to circulate when the main thyristors are turned off.

2) This diode helps prevent abrupt changes in current & voltage reducing stress on circuit components.

3) Specifically when thyristors turn off, the inductors tries to maintain current flow.

4) Without the freewheeling diode, this would lead to voltage spikes & potential damage.

5) A freewheeling diode placed across the inductive load will provide a path for the release of energy stored in inductor while load voltage drops to zero.

6) The freewheeling diode prevents the load voltage from becoming negative. whenever load voltage tends to go negative, freewheeling diode comes into play.

7) As a result, the load current is transferred from main thyristor to freewheeling diode, allowing the thyristor to regain its forward blocking capability.