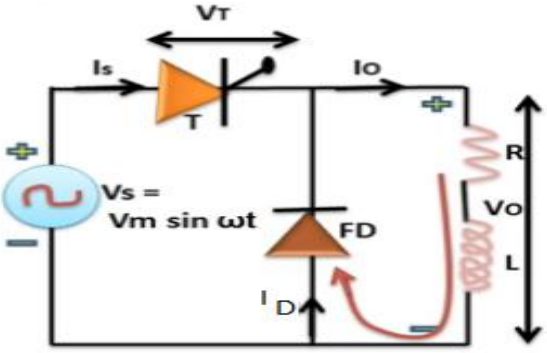
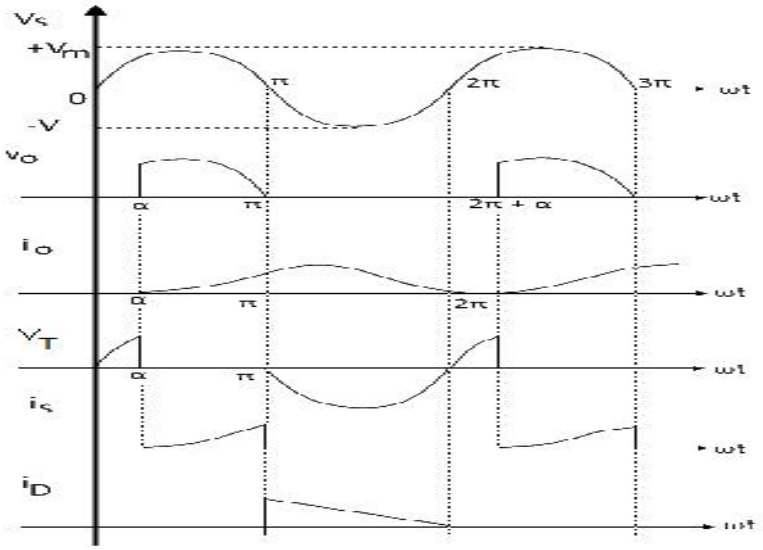
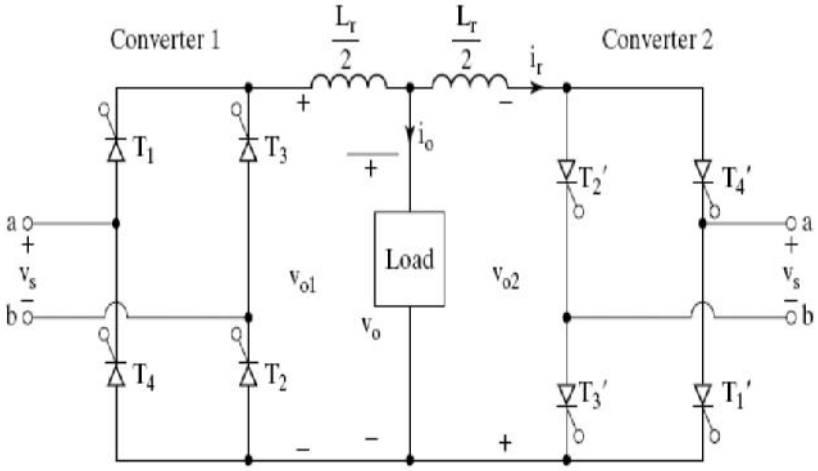
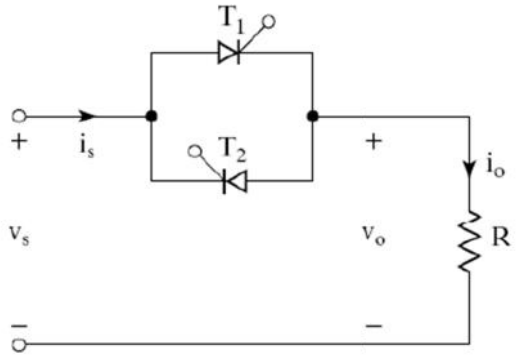
CMR INSTITUTE OF TECHNOLOGY	21EE54 - POWER ELECTRONICS Scheme & Solution	
Internal Assesment Test - II		
Answer Any FIVE FULL Questions		

	Marks	OBE	
		CO	RBT

1	Explain single phase half wave controlled converter with RL load and freewheeling diode, derive the expression for average and RMS voltage.   **During the positive half cycle** • The circuit consist of a thyristor T, a voltage source Vs, a diode FD across the RL load, an inductive load L and a resistive load R. • During the positive half cycle of the input voltage, the thyristor T is forward biased but it does not conduct until a gate signal is applied to it. • When a gate pulse is given to the thyristor T at ωt= α, it gets turned ON and begins to conduct. • When the thyristor is ON, the input voltage is applied to the load but due to the inductor present in the load, the current through the load builds up slowly. **During the negative half cycle** • During the negative half cycle, the thyristor T gets reverse biased. • At this instant i.e at ωt = π, the load current shift its path from the thyristor to the freewheeling diode. • When the current is shifted from thyristor to freewheeling diode, the thyristor turns OFF.	[10] 2 2 2	CO4	L2

2	Illustrate the single phase dual converter with neat diagram and waveform and also explain the significance of circulating current in dual converter. • Dual converter- the name itself indicates that it has two converters in it. • The dual converter system will provide four quadrant operation • Normally used in high power industrial variable speed drives. • In the case of a single phase full converter with inductive loads, the converter can operate in two different quadrants in the *Vdc* versus *Idc* operating diagram. • If two single phase full converters are connected in parallel and in opposite direction (connected in back to back) across a common load four quadrant operation is possible. Such a converter is called as a dual converter.  • Two single phase full converters are connected in parallel and in opposite direction (connected in back to back) across a common load **Converter 1** • The converter number 1 provides a positive dc output voltage and a positive dc load current, when operated in the rectification mode. • The converter number 1 provides a negative dc output voltage and a positive dc load current, when operated in the inverter mode. **Converter 2** • The converter number 2 provides a negative dc output voltage and a negative dc load current when operated in the rectification mode. • The converter number 2 provides a positive dc output voltage and a negative dc load current when operated in the inverter mode. • We can have **bi- directional load current and bi-directional dc output voltage.** • The magnitude of output dc load voltage and the dc load current can	[10] 2 2	CO4	L2

3	a. Explain the working of single phase full wave AC voltage controller with R load. Derive the expression for rms value of output voltage. b. List the applications of AC voltage controller.	[10]	CO4	L2



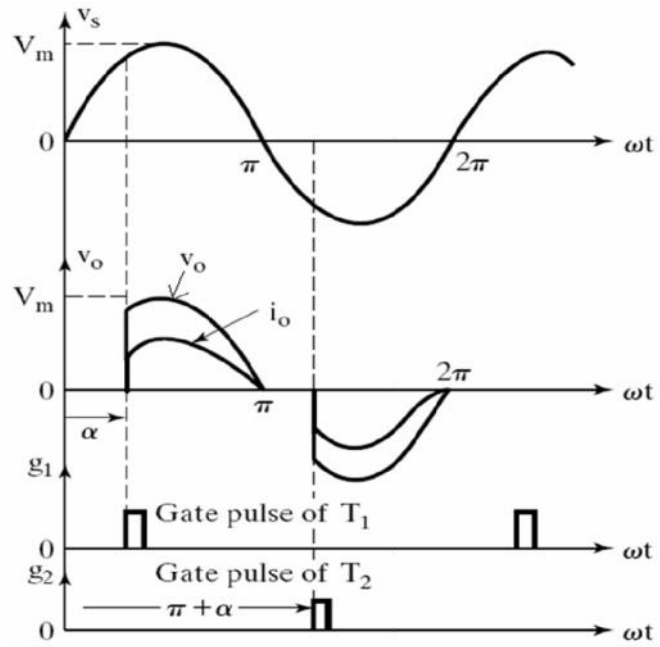
1

•Single phase full wave ac voltage controller is called bidirectional controller – AC Regulator.

•Single phase full wave ac voltage controller circuit using two Thyristors (T1 and T2) or a single triac is generally used in most of the ac control applications.

•The ac power flow to the load can be controlled in both the half cycles by varying the trigger angle ' **α** ' .

•The RMS value of load voltage can be varied by varying the trigger angle ' **α** ' .



2

•During Positive Half Cycle ωt = 0 to π

The thyristor *T*1 is forward biased during the positive half cycle of input ac supply.

•It can be triggered and made to conduct by applying a suitable gate trigger pulse '**α**'. only during the positive half cycle of input supply.

•When *T*1 is triggered it conducts and the load current flows through the

4a	An on-off controller with an input of 200 V, 50 Hz is connected to a resistive load of 10Ω. The circuit is operating with the switch ON for 20 cycles and OFF for 20 cycles. Determine (i) R.M.S output current (ii) Input power factor.	5	CO4	L3

4b) On-off Controller.

$V_s = 200V$; $f = 50Hz$

$R = 10\Omega$; $m = 20$ cycles ; $n = 20$ cycles.

(i) Rms output current

$t_{on} = n \times T$; $t_{off} = m \times T$

$K = \frac{n}{n+m} = \frac{20}{20+20} = \frac{20}{40} = \frac{1}{2} = 0.5$

$V_{orms} = \sqrt{K}\, V_s = \sqrt{0.5} \times 200 = 141.42V$

$I_{orms} = \frac{V_{orms}}{R} = \frac{141.42}{10} = 14.14A$

(ii) Input Power Factor.

$PF = \sqrt{K} = \sqrt{0.5} = 0.707$ lag

4 b	A single phase circulating current Dual converter is fed by a single phase 120V, 50Hz supply. The load is resistive. The peak current of converter 1 is 35 A. The firing angles are 30° and 150° respectively. If peak circulating current is 13A, Find (i) Inductance of current limiting reactor (ii) Load Resistance.	5	CO4	L4

4) Circulating Current mode dual converter:

$V_s = 120V$, $V_m = \sqrt{2}\, V_s = \sqrt{2} \times 120 = 169.7\,V$

$f = 50Hz$; R load.

$\omega = 2\pi f = 2 \times 3.14 \times 50 = 314.16$ rad/sec.

Peak Current of converter 1 = 35 A.

$\alpha_1 = 30°$; $\alpha_2 = 150°$

Peak Circulating Current $I_{rmax} = 13A$

(i) Inductance of Current limiting Reactor L_r.

$$I_{rmax} = \frac{2V_m}{\omega L_r}(1-\cos\alpha_1) = \frac{2 \times 169.7}{314.16 \times L_r}(1-\cos 30)$$

$$13 = \frac{339.4}{314.16 \times L_r} \times 0.134$$

(5 marks)

$$L_r = \frac{339.4 \times 0.134}{314.16 \times 13} = 0.01113H.$$

$L_r = 11.13\,mH$

(ii) Load Resistance R. (5 marks)

Peak current of Converter 1 = $I_{rmax} + I_p$

$35 = 13 + I_p$

$I_p = 35 - 13 = 22\,A.$

$I_p = \frac{V_m}{R} \Rightarrow R = \frac{V_m}{I_p} = \frac{169.7}{22} = 7.71\,\Omega.$

$R = 7.71\,\Omega$

R = 7.71 W

5	A single phase full wave AC voltage controller has a resistive load of R=6Ω and the input voltage is Vs= 120 V (rms), 50 Hz. The delay angle of thyristor T1 and T2 are equal α1 = α2 = π/2. Determine (i) RMS output voltage Vo (ii) The input Power Factor P.F. (iii) The average thyristor current (iv) The rms value of thyristor current (v) Output power	[10]	CO4	L3

Solution

$$\alpha = \frac{\pi}{2} = 90^0, \quad V_S = 120 \text{ V}, \quad R = 6\Omega$$

RMS Value of Output Voltage

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

$$V_o = 120 \left[\frac{1}{\pi} \left(\pi - \frac{\pi}{2} + \frac{\sin 180}{2} \right) \right]^{\frac{1}{2}}$$

$$V_o = 84.85 \text{ Volts}$$

RMS Output Current

$$I_o = \frac{V_o}{R} = \frac{84.85}{6} = 14.14 \text{ A}$$

Load Power

$$P_o = I_o^2 \times R$$

$$P_o = (14.14)^2 \times 6 = 1200 \text{ watts}$$

Input Current is same as Load Current

Therefore $I_s = I_o = 14.14$ Amps

Input Supply Volt-Amp $= V_s I_s = 120 \times 14.14 = 1696.8 \ VA$

Therefore

$$\text{Input Power Factor} = \frac{\text{Load Power}}{\text{Input Volt-Amp}} = \frac{1200}{1696.8} = 0.707 \ (lag)$$

Each Thyristor Conducts only for half a cycle

Average thyristor current $I_{T(Avg)}$

$$I_{T(Avg)} = \frac{1}{2\pi R} \int_{\alpha}^{\pi} V_m \sin \omega t . d(\omega t)$$

$$= \frac{V_m}{2\pi R} (1 + \cos \alpha) \; ; \qquad V_m = \sqrt{2} V_S$$

$$= \frac{\sqrt{2} \times 120}{2\pi \times 6} [1 + \cos 90] = 4.5 \text{ A}$$

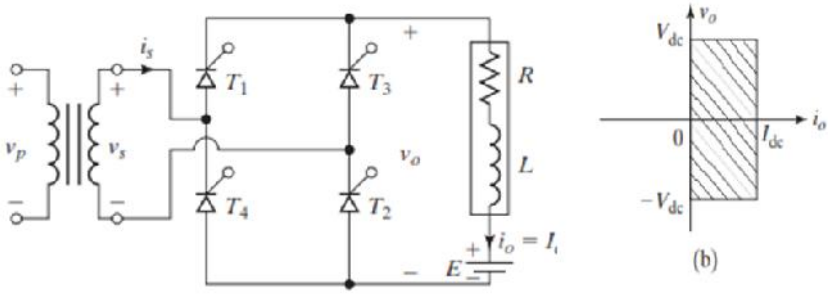
RMS thyristor current $I_{T(RMS)}$

$$I_{T(RMS)} = \sqrt{\frac{1}{2\pi} \int_{\alpha}^{\pi} \frac{V_m^2 \sin^2 \omega t}{R^2} d(\omega t)}$$

$$= \sqrt{\frac{V_m^2}{2\pi R^2} \int_{\alpha}^{\pi} \frac{(1 - \cos 2\omega t)}{2} d(\omega t)}$$

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

6	Explain single phase fully controlled converter with RLE load with neat diagram and waveform and derive the expression for average and RMS voltage.	[10]	CO4	L2



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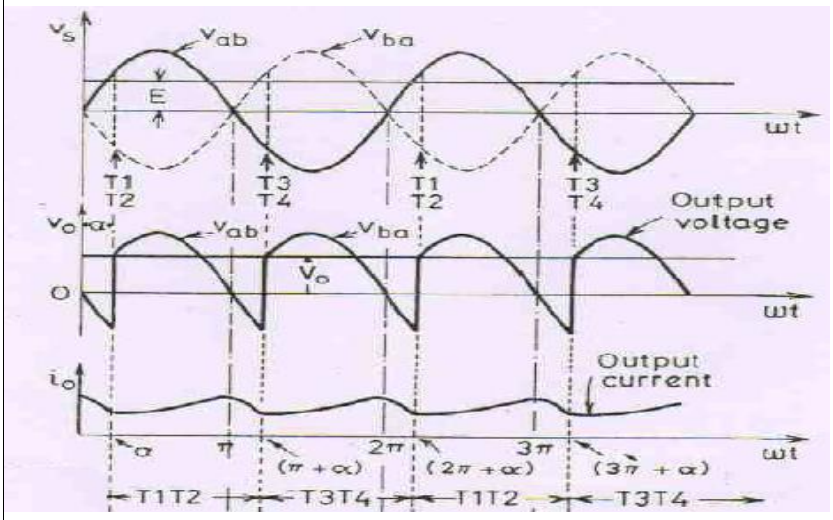

2

During the positive half-cycle

- The fully controlled bridge converter consists of four thyristors *T1, T2, T3 and T4* connected in the form of full wave bridge configuration.
- Each thyristor is controlled and turned on by its gating signal and naturally turns off when a reverse voltage appears across it (Line commutation or Natural commutation).
- Thyristors *T*1 and *T*2 are forward biased (0 to π);
- when these two thyristors are turned on simultaneously at ω*t* = α, the load is connected to the input supply through *T*1 and *T*2.
- Due to the inductive load, thyristors *T*1 and *T2* continue to conduct beyond ω*t* = π, even though the input voltage is already negative.
- *T*1 and *T2* conduct from ω*t* = α to π + α
- The output voltage across the load follows the input voltage vo = vm sin ω*t*

2

During the negative half-cycle of the input voltage

- Thyristors *T*3 and *T*4 are forward biased (π to 2π);

7	Explain phase angle control of AC voltage controller with unidirectional controller. **PHASE CONTROL (Phase angle Control)** • In phase control the Thyristors are used as switches to connect the load circuit to the input ac supply, for a part of every input cycle. • That is the ac supply voltage is chopped using Thyristors during a part of each input cycle. • The thyristor switch is turned on for a part of every half cycle, so that input supply voltage appears across the load and then turned off during the remaining part of input half cycle to disconnect the ac supply from the load. • By controlling the phase angle or the trigger angle 'α' (delay angle), the output RMS voltage across the load can be controlled. • The trigger delay angle 'α' is defined as the phase angle (the value of ωt) at which the thyristor turns on and the load current begins to flow. **PHASE CONTROL - Advantages** • Phase control Thyristors which are relatively inexpensive. • Due to ac line commutation or natural commutation, there is no need of extra commutation circuitry or components and the circuits for ac voltage controllers are very simple. • Triacs are more commonly used as a voltage controller. **PRINCIPLE OF PHASE CONTROL –** **Single phase Half wave AC voltage controller** • The basic principle of ac phase control technique is explained with reference to a single phase half wave ac voltage controller (unidirectional controller) circuit. • The half wave ac controller uses one thyristor and one diode connected in parallel across each other in opposite direction • Anode of thyristor T1 is connected to the cathode of diode D1 and the cathode of T1 is connected to the anode of D1 . • The output voltage across the load resistor 'R' and the ac power flow to the load is controlled by varying the trigger angle 'α'. **Single Phase Half wave AC Voltage controller (Unidirectional Controller)** 	10	CO4	L2