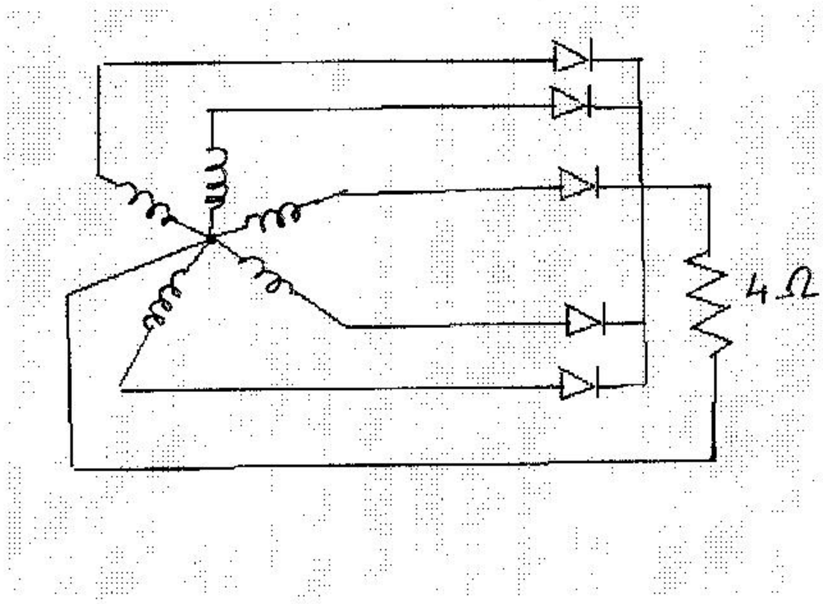
2. For the circuit shown below the power consumed in the load = 100W.
8marks



Find:

(i) The output rms voltage

$$P = I_{rms}^2 R \qquad 100 = I_{rms}^2 \times 4 \qquad I_{rms} = 5A$$

$$V_{rms} = 5 \times 4 = 20V$$

(ii) The maximum supply voltage

$$V_{rms} = \left[\frac{2}{\frac{2\pi}{5}} \int_0^{\frac{\pi}{5}} V_m^2 \cos^2 \omega t \, d\omega t\right]^{\frac{1}{2}} = V_m \left[\frac{5}{\pi}\left(\frac{\pi}{5} + \frac{1}{2}\sin\frac{2\pi}{5}\right)\right]^{\frac{1}{2}} = 0.937 V_m$$

$$\therefore V_m = 21.34$$

(iii) The output dc voltage

$$V_{dc} = \frac{2}{\frac{2\pi}{5}} \int_0^{\frac{\pi}{5}} V_m \cos \omega t \, d\omega t = V_m \cdot \frac{5}{\pi} \sin\frac{\pi}{5} = 0.9354 V_m = 19.963V$$

(iv) The rms of the current in each diode

$$I_{DRMS} = \frac{I_{rms}}{\sqrt{5}} = \frac{5}{\sqrt{5}} = 2.236 A$$

(v) The dc current in each diode

$$I_{DDC} = \frac{I_{dc}}{5} = \frac{19.963}{5 \times 4} = 0.99815 A$$

(vi) The transformer utilization factor (TUF)

$$TUF = \frac{P_{dc}}{5 V_s I_s} = \frac{\frac{19.963^2}{4}}{5 \times 21.34 \times \sqrt{2} \times 2.236} = 0.59$$

(vii) The power factor

$$PF = \frac{P_{ac}}{5 V_s I_s} = \frac{\frac{20^2}{4}}{5 \times 21.34 \sqrt{2} \times 2.236} = 0.59$$

(viii) The peak inverse voltage for each diode

$$PIV = \sqrt{5} V_m = \sqrt{5} \times 21.34 = 47.7 V$$

3.A single phase half wave controlled rectifier with an inductive load. $V_s = 230V$, f = 50Hz, R= 10Ω and L=0.1H **8marks**

(i) Starting from the differential equation, derive the expression for the current as function of the delay angle α.

$$L\frac{di}{dt} + Ri = V_m \sin \omega t$$

$$i(\omega t) = \frac{V_m}{Z}\sin(\omega t - \theta) + A e^{-\frac{t}{L/R}}$$

At $\omega t = \alpha$ $i = 0$ $A = -\frac{V_m}{Z}\sin(\alpha - \theta)\, e^{\frac{\alpha}{\omega L/R}}$

$$i(\omega t) = \frac{V_m}{Z}\left[\sin(\omega t - \theta) - \sin(\alpha - \theta)\, e^{\frac{\alpha - \omega t}{\omega L/R}}\right]$$

(ii) Derive the relationship to find α as function of the conduction angle γ.

at $\omega t = \beta$. $i = 0$ $\beta = \gamma + \alpha$ $\frac{\omega L}{R} = \tan\theta = \pi$

$$\sin(\alpha + \gamma - \theta) = \sin(\alpha - \theta)\, e^{\frac{\alpha - \alpha - \gamma}{\omega L/R}}$$

$$\sin(\alpha - \theta)\cos\gamma + \sin\gamma\cos(\alpha - \theta) = \sin(\alpha - \theta)\, e^{\frac{-\gamma}{\tan\theta}}$$

$$\sin(\alpha - \theta)\left[\cos\gamma - e^{-\frac{\gamma}{\tan\theta}}\right] = -\sin\gamma\cos(\alpha - \theta)$$

$$\tan(\alpha - \theta) = \frac{\sin(\alpha - \theta)}{\cos(\alpha - \theta)} = \frac{\sin\gamma}{e^{-\frac{\gamma}{\tan\theta}} - \cos\gamma}$$

(iii) Find the value of the delay angle α for a conduction angle γ of 120° $= \frac{2\pi}{3}$

$$\theta = \tan^{-1}\frac{2\times 50\times 0.1\pi}{10} = 72.34^\circ$$

$$\tan(\alpha - 72.34^\circ) = \frac{\sin 120}{e^{-\frac{2\pi}{3\pi}} - \cos 120^\circ}$$ $\alpha = 112.86^\circ$

(iv) Find the distinction angle β

$$\beta = \alpha + \gamma = 112.86 + 120 = 232.86^\circ$$

(v) Give the equation of the current for the above delay angle in a simplified form

$$i = \frac{230\sqrt{2}}{32.97}\left[\sin(314t - 72.34^\circ) - \sin(112.86 - 72.34)\, e^{\frac{1.95 - 314t}{\pi}}\right]$$

$$= 9.86 \sin(314t - 72.34^\circ) - 12 e^{-100t}$$

(vi) Calculate the dc output voltage $\alpha = 1.95\ rad \quad \beta = 4.05\ rad$

$$V_{dc} = \frac{V_m}{2\pi}\int_{1.95}^{4.05} \sin\omega t \, d\omega t = \frac{V_m}{2\pi}\left[\cos 1.95 - \cos 4.05\right]$$

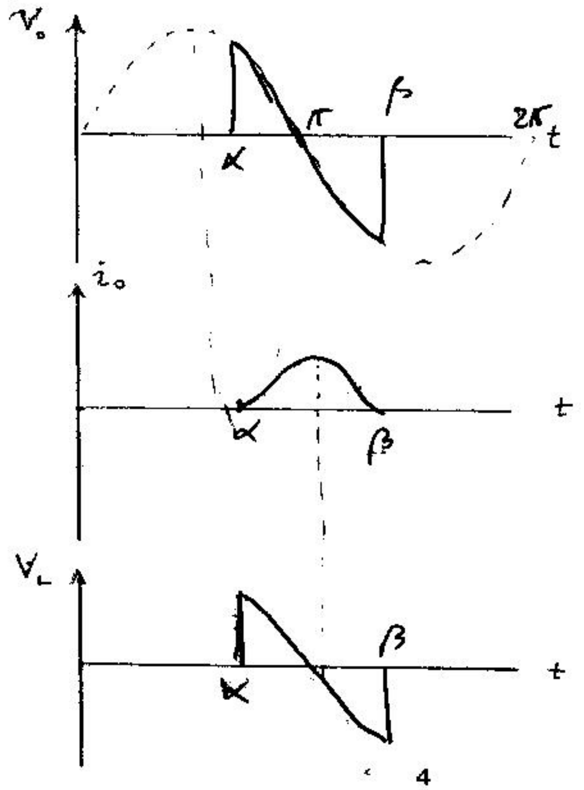
$$= 11.14\ V$$

(vii) Give the equation of the voltage across the inductance in a simplified form

$$V_L = L\frac{di}{dt} = 0.1\left[9.86 \times 314 \cos(314 - 72.34) + 12 \times 100\, e^{-100t}\right]$$

$$= 309.7 \cos(314 - 72.34) + 120 e^{-100t}$$

(viii) Sketch the waveforms of the output voltage, current and voltage across the inductance



4. For a full wave bridge controlled rectifier with RL load, R= 10 Ω , L= 0.0318H V_s =230V and f=50Hz . It is required to get a dc output voltage of 200V

8marks

(i) Find the necessary firing angle α

$\tan\theta = \frac{\omega L}{R} = \frac{2\pi \times 50 \times 0.0318}{10}$ $\therefore \theta = 45^\circ$

For continuous Voltage output $V_{dc} = \frac{1}{\pi}\int_{\alpha}^{\alpha+\pi} V_m \sin\omega t = \frac{2V_m\cos\alpha}{\pi}$

$200 = \frac{2 \times 230\sqrt{2}}{\pi}\cos\alpha$ $\alpha = 14.985^\circ$ $\therefore \alpha < \theta$ continuous

(ii) Find the rms value of the output current

For $\alpha \cong 15^\circ$ From graph

$V_2 = 0.45 V_m = 0.45 \times 230\sqrt{2} = 146.4$

$V_4 = 0.12 V_m = 0.12 \times 230\sqrt{2} = 39$

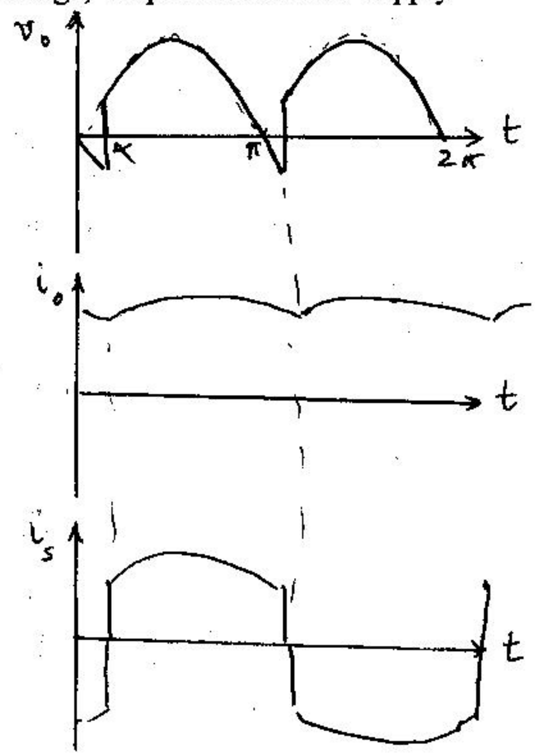
$V_0 = 200$

n	V_n	Z_n	I_n	I_{rms}
0	200	20	20	20
2	146.4	22.3	6.56	$\frac{6.56}{\sqrt{2}}$
4	39	41.23	0.945	$\frac{0.945}{\sqrt{2}}$

$$I_{rms} = \sqrt{20^2 + \left(\frac{6.56}{\sqrt{2}}\right)^2 + \left(\frac{0.945}{\sqrt{2}}\right)^2}$$

$= 20.53A$

(iii) Sketch the waveforms for the output voltage, output current and supply current



(iv) Find the output power

$$P_o = I_{rms}^2 R = 20.53^2 \times 10$$
$$= 4215W$$

(v) Find dc current in each thyristor

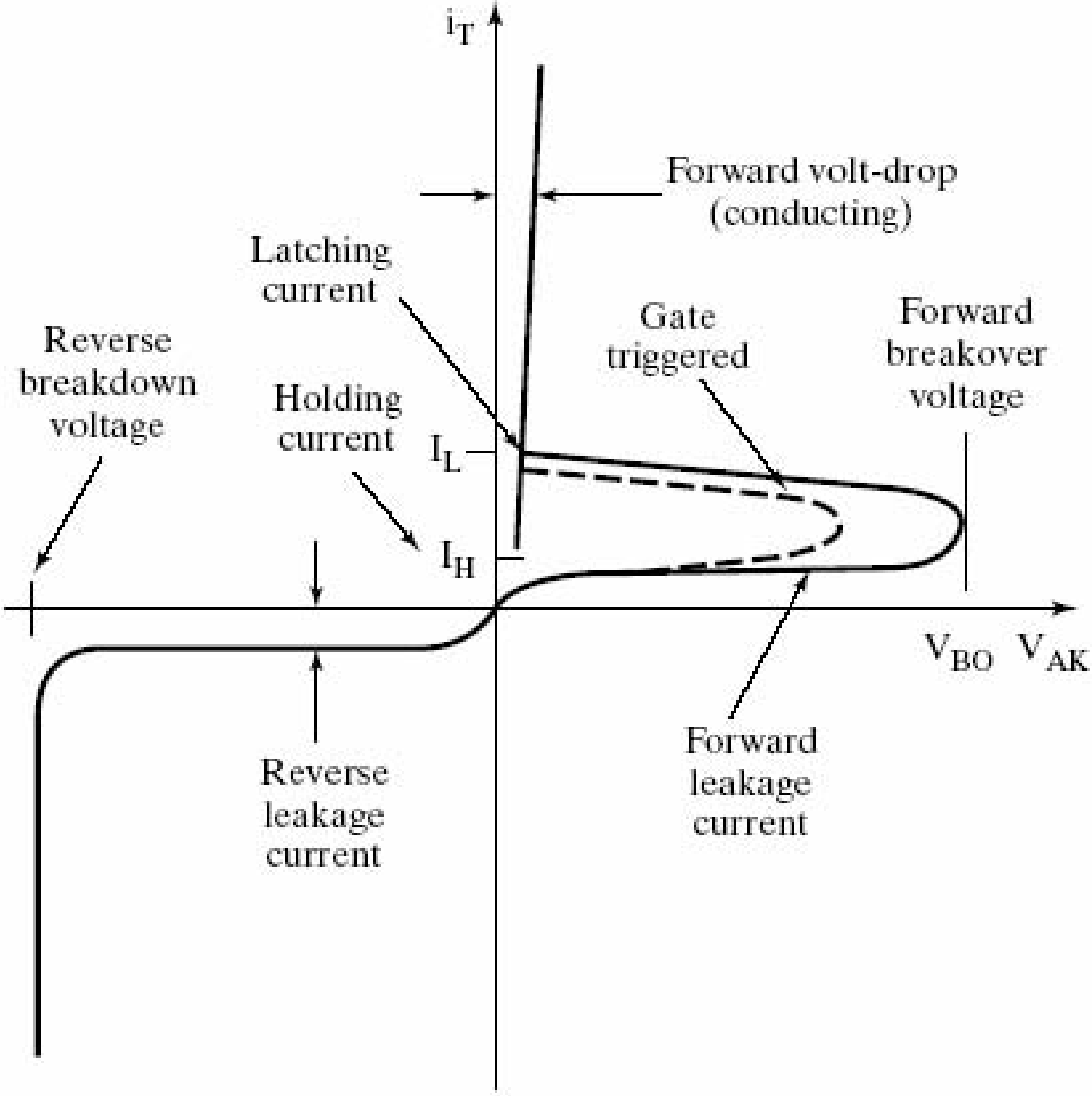
$$I_{DC} = \frac{200}{10} = 20A \qquad I_{DC\,TH} = \frac{I_{DC}}{2} = \frac{20}{2} = 10A$$

(vi) Find the rms value of the current in each thyristor

$$I_{RMS\,TH} = \frac{I_{RMS}}{\sqrt{2}} = \frac{20.53}{\sqrt{2}} = 14.52$$

(vii) Find the rms vaue of the supply current

$$I_s = I_{RMS} = 20.53A$$



i_T
Forward volt-drop
(conducting)
Latching
current
Gate
triggered
Forward
breakover
voltage
Reverse
breakdown
voltage
Holding
current
I_L
I_H
V_{BO}
V_{AK}
Reverse
leakage
current
Forward
leakage
current