... following by marking ✓ for correct answer and X for wrong answer. If you are not sure leave blank

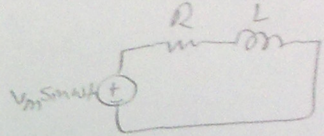
4 marks (0.5 mark per question)

1	GTO produces a lot of electromagnetic noise	X
2	Gate trigger domain of all possible triggering points in the gate trigger characteristics become bigger at higher temperatures	✓
3	Gate input characteristics domain becomes bigger if the pulse duration is longer	X
4	A snubber capacitor across a semiconductor switching device gives an overshoot in the voltage when turning ON	X
5	Latching current is always greater than holding current	✓
6	TRIAC's should never be used in dimmers because they are not sensitive to gate currents	X
7	Dual single phase full converters operate only in two quadrants	X
8	Circulating current can be reduced in dual single phase full converter by adding capacitors in series with the load	✓

2. A single phase half wave controlled rectifier with an RL load.

(i) Starting from the differential equation derive the equation for the load current as a function of time and the firing angle α. **10marks**

$$V_m \sin\omega t + iR + L\frac{di}{dt} = 0$$



$$i(\omega t) = \frac{V_m}{\sqrt{R^2+\omega^2L^2}}\sin(\omega t-\theta) + A e^{\frac{-t}{L/R}}$$

$$i(\omega t)\Big|_{\omega t=\alpha} = 0 \Rightarrow 0 = \frac{V_m}{Z}\sin(\alpha-\theta) + A e^{\frac{-\alpha}{\omega L/R}}$$

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

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

(ii) Derive the equation which enables to find the firing angle α as a function of the conduction angle γ and the phase angle θ.

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

Given that the supply voltage is 230V rms, f = 50Hz, R = 100Ω, L = 0.5 H. For a conduction angle $\gamma = 120°$; Find the following:

(iii) The values of θ, α and β.

$$\theta = \tan^{-1}\left(\frac{\omega L}{R}\right) = \tan^{-1}\left(\frac{2\pi \times 50 \times 0.5}{100}\right) = 57.5° = 1.003 \text{ rad.}$$

$\gamma = \beta - \alpha$

$\gamma = 120° = \frac{2\pi}{3} = 2.0$

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

$$1.75\tan(\alpha-\theta) = \frac{0.866}{e^{-\frac{2.1}{1.57}} - (-0.5)} = 1.135$$

$\tan(\alpha - \theta) = 0.65 \Rightarrow \alpha - 57.5 = 33 \Rightarrow \alpha = 90.5° \Rightarrow \beta = \alpha + \gamma = 210°$

(iv) The equation for the current as function of time

$\frac{\frac{\pi}{2} - \omega t}{1.57}$

$$i(\omega t) = \frac{230\sqrt{2}}{\sqrt{100^2 + (2\pi \times 0.5 \times 50)^2}}\left[\sin(\omega t - 57.5°) - \sin(90.5 - 57.5°)\, e\right.$$

1.75

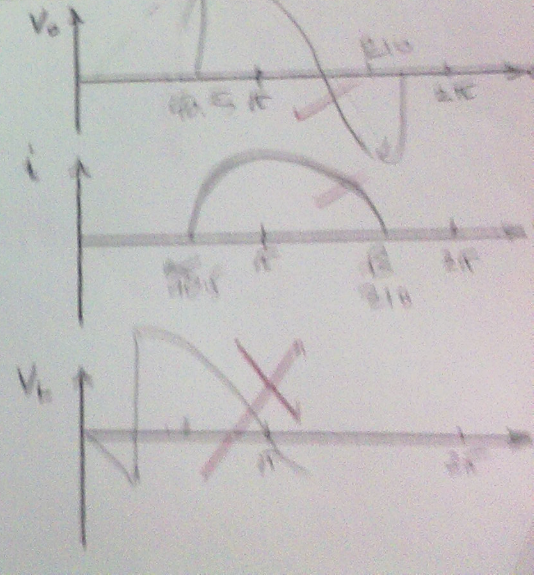
(v) The value of the output dc voltage

$$V_{dc} = \frac{V_m}{2\pi}(\cos\alpha + 1) = \frac{230\sqrt{2}}{2\pi}(\cos 90.5 + 1) = 51.76$$

(vi) The equation of the voltage across the inductance as function of time

$= L \frac{d\,i(\omega t)}{d\,\omega t} = 1.75\left[\cos(\omega t - 97.5) - 0.544 * e^{...}\right]$

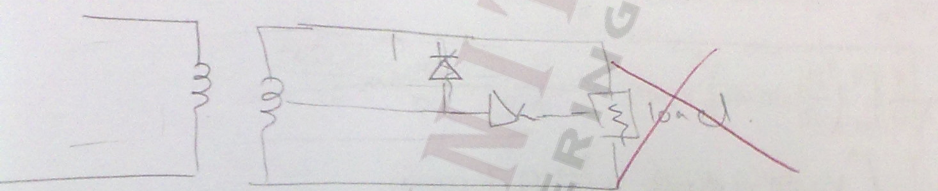
(vii) Draw the waveforms for the output voltage, current and inductance voltage



3. A single phase full-wave bridge converter with a solar cells source and an RL load. The load is highly inductive. It is required to operate the converter as an inverter.

(i) Draw the circuit diagram

6marks



(ii) If the solar cells are supplying power of 2000W at 200V and the series resistance $=1\Omega$, the secondary voltage of the transformer = 230V (rms), find the firing angle required to get the above power from the solar cells.

$I = \frac{2000}{200} = 10A$; Vdrop in resistance $= 10 \times 1 = 10$ V

$V_{dc} = -200 + 10 = \frac{2V_m}{\pi} \cos\alpha \Rightarrow \cos\alpha = \frac{-190\pi}{2 \times 230\sqrt{2}} =$

$\Rightarrow \alpha = 156.57$

(iii) What will be the power returned to the transformer then? Neglect the voltage drop across the thyristors.

$P_{transform} = (200)10 - (10)^2 \times 1 = 1900$ watt.

(iv) If the above firing angle is increased by 5°, Find the new current

$V_{dc} = \frac{2V_m}{\pi} \cos(5 + 156.57) = -196.452$

$I = \frac{V_{old} + V_{new}}{R} = \frac{200 - 196}{1} = 3.54$ A

(v) What will be the power returned to the transformer then?

$P_{new} = -196 \times 3.54 + (3.54)^2 \times 1 = -681$ wa

(vi) Find the current in each thyristor in this case.

Idc = ... A

(i) The firing angle necessary to get the above dc voltage

$\alpha > 30$ discontinuous.

$V_{dc} = \frac{3V_m}{2\pi}(1 + \cos(30+\alpha))$

$200 = \frac{3 * 400\sqrt{2}}{2\pi}(1 + \cos(30^\circ+\alpha))$

$0.74 = 1 + \cos(30+\alpha)$

$-0.26 = \cos(30+\alpha) \Rightarrow \cos^{-1}(-0.26) = 30^\circ + \alpha$

$105^\circ = 30 + \alpha \Rightarrow \alpha = 75^\circ \Rightarrow \alpha = 1.31$ rad

1.31 ra

(ii) The rms value of the output voltage

$V_{rms} = \sqrt{3}\, V_m \sqrt{\frac{5}{24} - \frac{\alpha}{4\pi} + \frac{1}{8\pi}\sin\left(\frac{\pi}{3} + 2\alpha\right)}$

$V_{rms} = \sqrt{3} * 400\sqrt{2}\sqrt{\frac{5}{24} - \frac{1.31}{4\pi} + \frac{1}{8\pi}\sin(210)}$

$V_{rms} = 284.3V$

6

(iii) The average thyristor current

$I_{dc_{Th.}} = \frac{V_{dc}}{R*3} = \frac{200}{3*200} = 0.$

= 200 given

(iv) The rms thyristor current

$I_{rms} = \frac{V_{rms}}{\sqrt{3}R} = \frac{284.3}{\sqrt{3} * 200} = 0.82$ A