



Complete, fold and seal
(see note 2 below)

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Instructions to Candidates

1. Please give the information requested in the boxes below.
2. Enter your name in the space provided to the right, fold over and seal down (using the label provided) to hide your name.
3. The answers must be legibly written. The Examiners can either ignore illegible script or have it typed and the expense of typing charged to the candidate.
4. Write your answers in ink.
5. Begin each answer on a fresh page. Do all rough work in the answer book and cross it through.
6. No part of this book is to be torn out; it must be handed in complete.
7. If more books than one are used, fasten them together using the tags available from the invigilator(s).
8. **Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the examination venue.**

List the numbers of the questions you have attempted	Office Use
1	22
2	12
4	0
5	0
Total	34

MARK
AGREED

1. (A) i)
1. Hysteresis losses
 2. Eddy current losses

1. Hysteresis losses occur within the core of a transformer and is minimized due to the material within the core. The losses are equal to the B-H hysteresis curve area. The losses are proportional to the area of the curve. The smaller the curve area the smaller the losses.

2. Eddy current losses occur within the transformer core due to the change in magnetic flux. To minimize the losses the core is built up of laminations, where the laminations are then insulated from each other.

ii)

$$f = 60 \text{ Hz}$$

$$V = 5500/200 \text{ V}$$

$$\phi = 0.075$$

$$E_2 = 4.44 f N_2 \phi_{\max}$$

$$\therefore N_2 = \frac{E_2}{4.44 f \phi_{\max}} = \frac{200}{4.44 \times 60 \times 0.075}$$

$$= 10.010 \text{ (10) Turns}$$

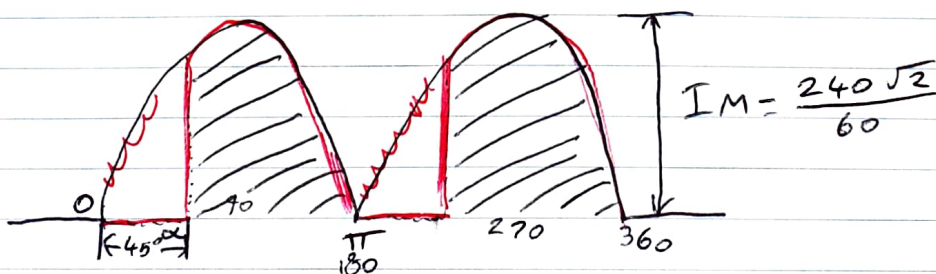
$$N_1 = N_2 \frac{V_1}{V_2}$$

$$N_1 = 10 \times \frac{5500}{200} = 275 \text{ Turns}$$

1. (B) i) $M1 = P_1 = 5.5 \times 0.78 = 4.29 \text{ kW} \checkmark$
 $Q_1 = \sqrt{5.5^2 - 4.29^2} = 3.44 \text{ kVAR} \checkmark$
 $M2 = P_2 = 15.2 \times 0.85 = 12.92 \text{ kW} \checkmark$
 $Q_2 = \sqrt{15.2^2 - 12.92^2} = 8.01 \text{ kVAR} \checkmark$
 $P_3 = 3.5 \times 3 = 10.5 \text{ kW} \checkmark$
 $P_T = P_1 + P_2 + P_3 = 4.29 + 12.92 + 10.5 = 27.71 \text{ kW} \checkmark$
 $Q_T = Q_1 + Q_2 = 3.44 + 8.01 = 11.45 \text{ kVAR} \checkmark$
 $S = \sqrt{27.71^2 + 11.45^2} = 29.98 \text{ kVA} \checkmark$
 Secondary line current $= \frac{S}{\sqrt{3} V_2} = \frac{29980}{\sqrt{3} \times 420} = 71.38 \text{ A} \times$
 Primary line current $= \frac{S}{\sqrt{3} V_1} = \frac{29980}{\sqrt{3} \times 11000} = 2.73 \text{ A} \checkmark$
 ii) Power factor $= \frac{P_T}{S} = \frac{27.71}{29.98} = 0.924 \text{ P.f.} \times$ *correct answer*

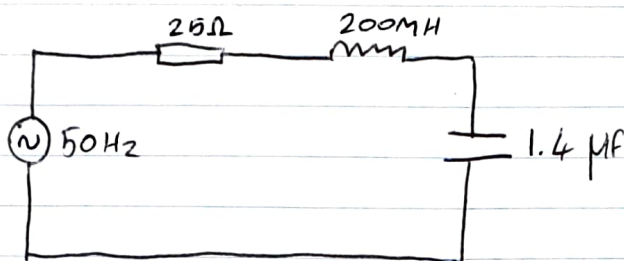
2. (A) i) Thyristors manufacturers specify di/dt as it indicates the maximum current switching, therefore if the limit is exceeded there will be uneven heat within the thyristor as heat will build up within the junction of the thyristor, where this may cause the thyristor to fail. dv/dt is specified as it determines the maximum voltage rise time for switching the thyristor.
- ii) Ensuring di/dt does not exceed its current ^{rate} limit a series inductor can be added to its circuit. ~~Di/dt~~ To ensure dv/dt does not exceed its voltage ^{rate} limit a RC ^{weber} ~~snubber~~ ^{network} ~~circuit~~ can be added between the anode and the cathode of the thyristor.

(B) i)



ii) $I_{Rms} = \frac{W}{R} = \frac{870}{60} = 14.5 \text{ A} \checkmark$ $I_{Rms} = \sqrt{14.5} = 3.81$
 iii) $\frac{1}{\pi} \int_0^\pi I \sin \theta d\theta$ Where $f_n = \frac{W}{R}$
 $\frac{\sqrt{2} \times 240}{\pi \times 60} (\cos 45) = 0.9$

④ (a)



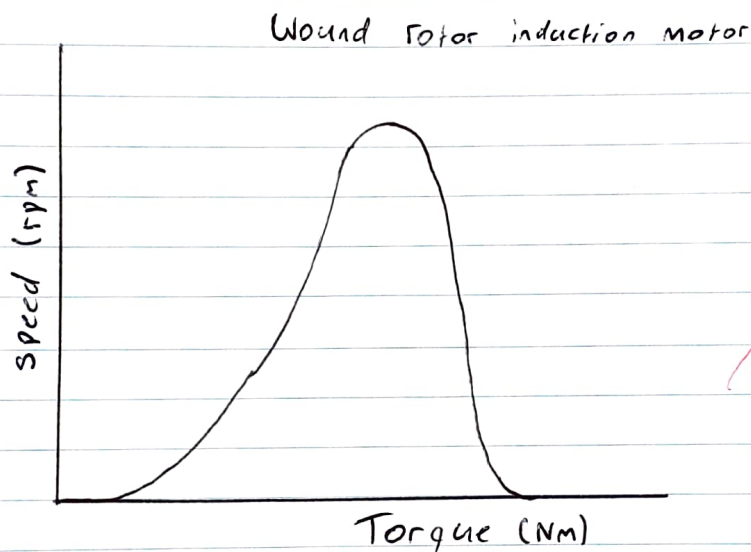
$$R_1 = 25\Omega$$

$$L_1 = 200\text{mH}$$

$$C_1 = 1.4\mu\text{F}$$

$$f = 50\text{Hz}$$

⑤ (a)



For the starting of a 3-phase wound induction motor the external rotor resistance is used to start the motor. As there is an resistance on the motor shaft the motor itself takes time to ramp up and whilst it ramps up the motor torque increases as shown on the diagram above. Having a ~~load~~ resistive load on the motor is heating as the motor has time to start up where there will not be a sudden ~~for~~ jerk to the motor.

$$(b) R = \frac{V}{0.6 + j7\Omega}$$

$$\text{Primary Stator voltage} = \frac{V_{in}}{\text{Ratio}_1} = \frac{415}{1} = 415\text{V}$$

$$\text{Secondary stator voltage} = \frac{V_{in}}{\text{Ratio}_2} = \frac{415}{0.6} = 518.75\text{V}$$