



Complete, fold and seal
(see note 2 below)

SMITHAM

AERON

12 Pages

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.**

1	Student Number	2017197
2	Title of Examination Paper	SG Power and Machines
3	Module Code	SGEES006
4	Date and Time of Examination	4/5/23 09:30 - 12:00
5	Examination Venue	CSB Craig Campus
6	Seat Number	23
7	Number of Answer Books handed in	1

List the numbers of the questions you have attempted	Office Use
1	25
2	25
3	25
4	3
Total	78

✓
✓
✓
✓

✓ MARK
ASSED

- 1a) i) The two types of losses that occur in the core of a transformer are Eddy current losses and hysteresis losses.
- Eddy current losses can be minimised by laminating the core. Each lamination is insulated from the other.
- Hysteresis losses can be minimised by choice of core material. The loss is proportional to the area of the B-H (Hysteresis) loop. The narrower the loop, the lower the loss. ✓

6 ✓

ii) $E_2 = 4.44 F N_2 \phi_{\max}$

$$N_2 = \frac{E_2}{4.44 F \phi_{\max}}$$

$$N_2 = \frac{200}{4.44 \times 60 \times 0.075}$$

$$= 10.01 \text{ turns} \quad \checkmark$$

$$N_1 = N_2 \times \frac{E_1}{E_2}$$

$$N_1 = 10 \times \frac{5500}{200}$$

$$N_1 = 275 \text{ turns} \quad \checkmark$$

4 ✓

1b) i) Single-phase loads = $3 \times 3.5 \text{ kW}$
 $= 10.5 \text{ kW}$
 $M1: S_1 = 5.5 \text{ kVA}, P_1 = 5.5 \times 0.78 = 4.29 \text{ kW}, Q_1 = \sqrt{5.5^2 - 4.29^2} = 3.44 \text{ kVAR}$

$M2: S_2 = 15.2 \text{ kVA}, P_2 = 15.2 \times 0.85 = 12.92 \text{ kW}, Q_2 = \sqrt{15.2^2 - 12.92^2} = 8.01 \text{ kVAR}$

$P_T = 10.5 + 12.92 + 4.29$
 $= 27.71 \text{ kW}$

$Q_T = 3.44 + 8.01 = 11.45 \text{ kVAR}$

$S_T = \sqrt{P_T^2 + Q_T^2}$
 $= \sqrt{27.71^2 + 11.45^2}$
 $= 29.98 \text{ kVA}$

$I_{\text{sec}} = \frac{29980}{\sqrt{3} \times 400}$
 $= 43.27 \text{ A}$

$I_{\text{sec}} = \frac{29980}{\sqrt{3} \times 420}$
 $= 41.21 \text{ A}$ ✓

$I_{\text{pri}} = \frac{29980}{\sqrt{3} \times 11000}$
 $= 1.57 \text{ A}$ ✓

ii) Power Factor = $\frac{P_T}{S_T}$
 $= \frac{27710}{29980}$
 $= 0.92 \text{ lagging}$ ✓

13

2

2a)i) di/dt values are specified to show the maximum rate of rise in current, that when triggered, will not cause unequal distribution of current, causing hot spots in the device junctions and possibly causing device failure.

(4)



dV/dt values are specified to show the maximum rate of rise in anode-cathode voltage that will not trigger the device.

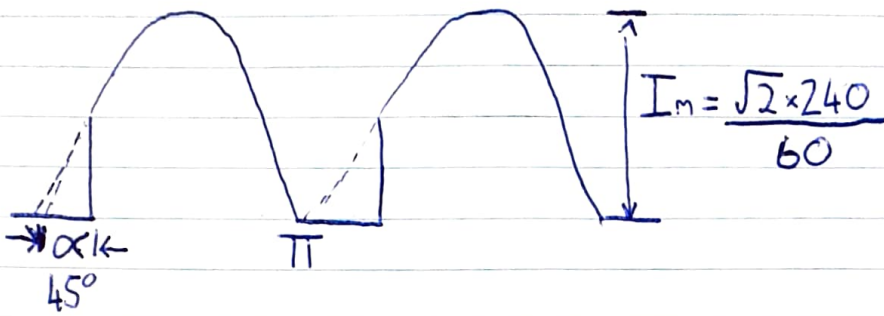
ii) di/dt can be controlled by the addition of a series inductor.

(4)

dV/dt can be controlled by the addition of an RC series snubber network connected between the anode and cathode.



2 bi)



$$\begin{aligned} \text{ii) } I_{rms} &= \frac{P}{R} \\ &= \frac{870}{60} \\ &= 14.5 \text{ A} \\ I_{rms} &= \sqrt{14.5} \\ &= 3.808 \text{ A} \end{aligned}$$

$$\text{iii) } I_{mean} = \frac{1}{\pi} \int_{\alpha}^{\pi} I_m \sin \theta d\theta \quad \text{where } I_m = \frac{V_m}{R}$$

$$I_{mean} = \frac{V_m}{\pi R} \int_{\alpha}^{\pi} \sin \theta d\theta$$

$$I_{mean} = \frac{V_m}{\pi R} [-\cos \theta]_{\alpha}^{\pi}$$

$$I_{mean} = \frac{V_m}{\pi R} [1 + \cos \alpha]$$

$$I_{mean} = \frac{\sqrt{2} \times 240}{\pi \times 60} [1 + \cos 45^\circ]$$

$$I_{mean} = 3.074 \text{ A}$$

5

✓

3

✓

9

✓

$$3i) R_A = 0.48 \Omega$$

$$T_L = 68 \text{ Nm}$$

$$b = 0.02 \text{ Nm/rad/s}$$

$$\omega_m = 2100 \times \frac{2\pi}{60} = 219.91 \text{ rad/s}$$

$$T_m = T_L + b\omega_m = 68 + 0.02(219.91) = 72.4 \text{ Nm}$$

$$\text{Since } T_m = k_m I_a$$

$$\therefore k_m = \frac{T_m}{I_a} = \frac{72.4}{74.5}$$

$$k_m = 0.972 \text{ Nm/A}$$

$$V_a = E_a + I_a R_a$$

$$250 = E_a + 74.5(0.48)$$

$$E_a = 250 - 35.76$$

$$E_a = 214.24 \text{ V}$$

$$\text{Since } E_a = k_e \omega_m$$

$$k_e = \frac{E_a}{\omega_m} = \frac{214.24}{219.91}$$

$$k_e = 0.974 \text{ V/rad/s}$$

$$ii) T_m = T_L + b\omega_m \quad \text{where } T_m = k_m I_a$$

$$0.972 I_a = 80 + 0.02(\omega_m)$$

$$I_a = \frac{80 + 0.02(\omega_m)}{0.972} \quad \text{--- (1)}$$

$$V_m = E_a + I_a R_a \quad \text{where } E_a = k_e \omega_m$$

$$250 = 0.974 \omega_m + 0.48(I_a) \quad \text{--- (2)}$$

Sub (1) into (2)

$$250 = 0.974 \omega_m + \frac{0.48(80 + 0.02 \omega_m)}{0.972}$$

$$250 = 0.974 \omega_m + 39.51 + 0.01 \omega_m$$

$$250 - 39.51 = 0.974 \omega_m + 0.01 \omega_m$$

$$210.49 = 0.984 \omega_m$$

$$\omega_m = \frac{210.49}{0.984}$$

$$\omega_m = 213.91 \text{ rad/s}$$

sub into (1)

(5)

(3)

3ii) $W_m = 213.91 \text{ rad/s}$

cont.)

$$I_a = \frac{80 + 0.02(213.91)}{0.972}$$

$$I_a = 86.71 \text{ A}$$

3iii) ~~Load at 68 Nm~~

$$P_m = T_m \times \omega_m$$

$$= 68 \times 219.91$$

$$= 14953.88 \text{ W}$$

$$P_e = V_a \times I_a$$

$$= 250 \times 74.5$$

$$= 18625 \text{ W}$$

$$\% \text{ efficiency} = \frac{P_m \times 100}{P_e} = \frac{14953.88 \times 100}{18625}$$

$$= 80.3\%$$

~~Load at 80 Nm~~

$$T_m = T_c + b \omega_m$$

$$= 80 + 0.02(213.91)$$

$$= 84.3 \text{ Nm}$$

3iii) Load at 68Nm
 $P_m = T_m \times \omega_m$
 $= 72.4 \times 219.91$
 $= 15921.48 \text{ W}$

$$P_e = V_a \times I_a$$

$$= 250 \times 74.5$$

$$= 18625 \text{ W}$$

$$\% \text{ efficiency} = \frac{P_m \times 100}{P_e} = \frac{15921.48 \times 100}{18625}$$

$$= 85.48\% \quad \checkmark$$

4
✓

Load at 80Nm
 $T_m = T_L + b\omega_m$
 $= 80 + 0.02(213.91)$
 $= 84.3 \text{ Nm}$

$$P_m = T_m \times \omega_m$$

$$= 84.3 \times 213.91$$

$$= 18032.61 \text{ W}$$

$$P_e = V_a \times I_a$$

$$= 250 \times 86.71$$

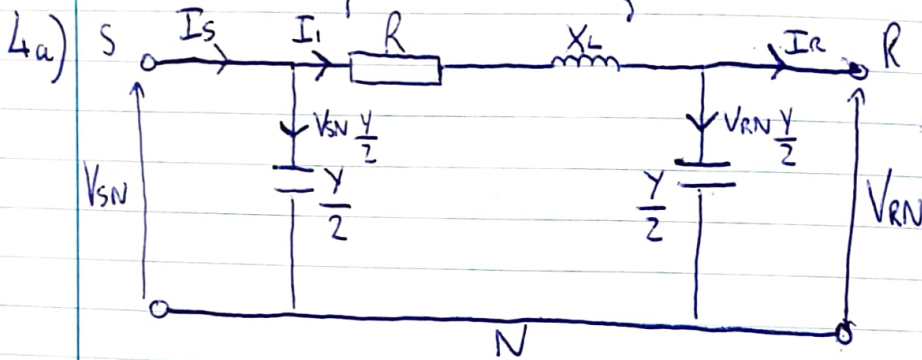
$$= 21677.5 \text{ W}$$

$$\% \text{ efficiency} = \frac{P_m \times 100}{P_e} = \frac{18032.61 \times 100}{21677.5}$$

$$= 83.2\% \quad \checkmark$$

5
✓

This is not the nominal T



$$\begin{aligned}\text{Series Impedance} &= R + j\omega L \\ &= 25 + j \times 2\pi \times 50 \times 0.2 \\ &= 25 + j62.83\end{aligned}$$

$$\begin{aligned}|Z| &= \sqrt{25^2 + 62.83^2} \\ &= 67.62 \Omega\end{aligned}$$

$$\begin{aligned}\angle Z &= \tan^{-1}\left(\frac{62.83}{25}\right) \\ &= 68.3^\circ\end{aligned}$$

$$Z = 67.62 \angle 68.3^\circ \Omega \quad \checkmark$$

$$\begin{aligned}\text{Shunt Admittance, } Y &= j\omega C \\ &= j \times 2\pi \times 50 \times 1.4 \\ &= 0.44 \angle 90^\circ \text{ S} \quad \checkmark\end{aligned}$$



4b) Receiving end voltage