



Examination Answer Books

12 Pages

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.**

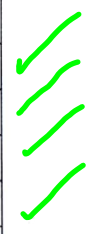
Complete, fold and seal
(see note 2 below)

SURNAME: PERRY

FORENAME(S): MATTHEW

1	Student Number	2024421
2	Title of Examination Paper	POWER + MACHINES
3	Module Code	SGEE5006
4	Date and Time of Examination	04/05/2023 09:30 - 12:00
5	Examination Venue	CS9
6	Seat Number	32
7	Number of Answer Books handed in	

List the numbers of the questions you have attempted	Office Use
1	25
2	25
3	22
4	4
Total	76



✓ MARK
AGREED
dy

i ai Two types of losses:

- Hysteresis which is due to the core material. The loss is proportional to the B-H hysteresis loop. The narrower the loop the lower the loss. By selecting a material such as silicon steel losses can be reduced.
- Eddy currents are due to the changing of magnetic flux within the core. Eddy currents can be minimized by laminating the core. The laminations should also be insulated from each other.

6



aii $E_2 = 4.44 f N \Phi_{max}$.

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

$$N_2 = 10.010 = 10 \text{ turns.}$$

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

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

4



bi single phase loads = $3.5 \times 3 = 10.5 \text{ kW}$

$$P_1 = 10.5 \text{ kW}$$

$$m_1 = 5.5 \text{ kVA}, p.f = 0.78$$

$$P_2 = 5.5 \times 0.78 = 4.29 \text{ kW}$$

$$Q_1 = \sqrt{V_a^2 - P_2^2} = \sqrt{5.5^2 - 4.29^2} = 3.4418 \text{ kvar}$$

$$m_2 = 15.2 \text{ kVA}, p.f = 0.85$$

$$P_3 = 15.2 \times 0.85 = 12.92 \text{ kW}$$

$$Q_2 = \sqrt{V_a^2 - P_2^2} = \sqrt{15.2^2 - 12.92^2} = 8.0071$$

$$P_{Total} = P_1 + P_2 + P_3 = 10.5 + 4.29 + 12.92 = 27.71 \text{ kW}$$

$$Q_{Total} = 3.4418 + 8.0071 = 11.4489 \text{ kvar}$$

$$S = \sqrt{P^2 + Q^2}$$

$$\sqrt{27.71^2 + 11.4489^2} = 29.9821$$

$$\text{primary } I = \frac{S}{\sqrt{3} \times E1} = \frac{29982}{\sqrt{3} \times 11000}$$

$$I_P = \cancel{165.6455} \text{ A} \quad 1.5736 \text{ A} \quad \checkmark$$

$$\text{Secondary } I = \frac{S}{\sqrt{3} \times E2} = \frac{29982}{\sqrt{3} \times 420}$$

$$I_S = 41.2146 \text{ A} \quad \checkmark$$

1 bii

$$\frac{P}{S} = \frac{27.71}{29982.1} = 0.92 \quad \checkmark$$

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2

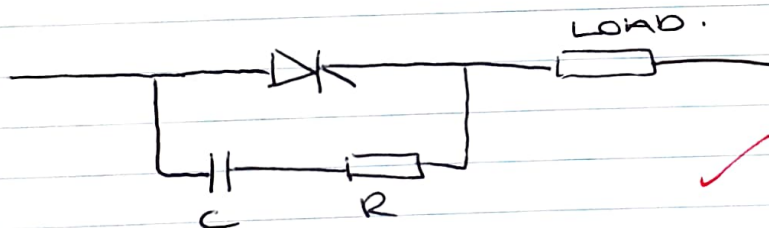
2ai Manufacturers specify di/dt values for their devices. di/dt specifies the maximum rate of rise of current. This is to prevent unequal current distribution and to prevent hotspots within device junctions.

dV/dt specifies the maximum rate of rise of voltage which will not trigger a device. This will help prevent false triggering.

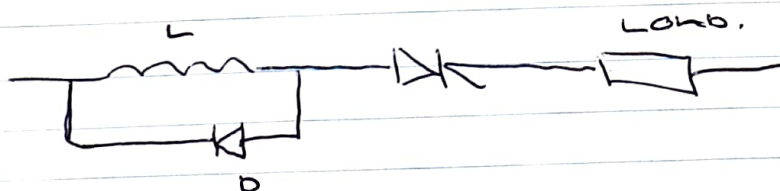
2aii To ensure that the di/dt value is not exceeded a series inductor can be placed as shown.



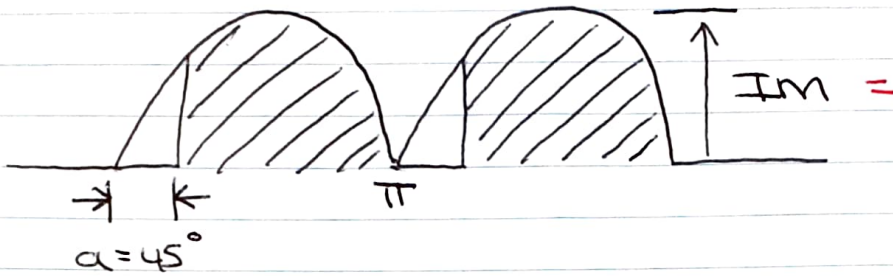
The dV/dt value can not be exceed by placing a parallel R-C circuit across the device. This RC circuit is also called a snubber network. AS shown.



Additionally a diode can be placed in the di/dt circuit to aid switch on.



2 bi



$$I_m = \frac{240}{60} \times \sqrt{2} = 5.6568 \text{ A}$$

2 bii

$$I_{\text{rms}}^2 = \frac{P}{R} = \frac{870}{60} = 14.5 \text{ A}^2$$

$$I_{\text{rms}} = 3.8078 \text{ A} \quad \checkmark$$

2 biii

$$I_{\text{mean}} = \frac{1}{\pi} \int_a^{\pi} I_m \sin \theta d\theta$$

$$\text{where } I_m = \frac{V_m}{R}$$

$$\frac{V_m}{\pi R} \int_a^{\pi} \sin \theta d\theta$$

$$\frac{V_m}{\pi R} \left[-\cos \theta \right]_a^{\pi}$$

$$\frac{V_m}{\pi R} \left[1 + \cos a \right]$$

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

$$= 1.8006 \times 1.7071 = 3.0738 \text{ k} \quad \checkmark$$

9
✓

3i Electrical

$$E_a = k_e \omega_m$$

$$V_a - E_a = I_a R_a.$$

$$\omega_m = \frac{\text{rpm}}{60} \times 2\pi = \frac{2100}{60} \times 2\pi = 219.911 \text{ rad/s.} \quad \checkmark$$

$$E_a = V_a - I_a R_a.$$

$$E_a = 250 - 74.5 \times 0.48$$

$$E_a = 214.24.$$

$$\frac{E_a}{\omega_m} = k_e \quad k_e = \frac{E_a}{\omega_m}$$

$$k_e = \frac{214.24}{219.911} = 0.9742 \quad \checkmark$$

mechanical.

$$T_m = k_m I_a.$$

$$\text{where } T_m = T_L + b \omega_m.$$

$$T_m = 68 + 0.02 \times 219.911 \\ = 72.3982$$

$$k_m = \frac{T_m}{I_a} = \frac{72.3982}{74.5}$$

$$k_m = 0.9718 \quad \checkmark$$

8
✓

3ii

$$V_a - E_a = I_a R_a.$$

$$V_a = E_a + I_a R_a.$$

$$\textcircled{1} \quad 250 = 0.9742 \omega_m + 0.48 I_a. \quad \checkmark$$

$$T_m = T_L + b \times \omega_m$$

$$0.9718 I_a = 80 + 0.02 \times \omega_m$$

$$\textcircled{2} \quad I_a = \frac{80 + 0.02 \times \omega_m}{0.9718}. \quad \checkmark$$

Sub 1 into 2.

$$250 = 0.9742 \omega_m + \frac{0.48(80 + 0.02 \omega_m)}{0.9718}.$$

you have added a zero

$$250 = 0.9742 \omega_m + 39.5143 + 0.0099 \omega_m. \quad \checkmark$$

$$250 - 39.5143 = 0.9742 \omega_m + 0.0099 \omega_m$$

$$210.4857 = 0.10732 \omega_m.$$

$$\omega_m = \frac{210.4857}{0.10732} = 1961.29 \text{ rad/s.} \quad \times$$

$$I_a = \frac{80 + 0.02 \times 1961.29}{0.9718}$$

$$I_a = 122.6855 \text{ A} \quad \times$$

*correct method
1 error
carried through*

7

3ii:

$$\% \eta = \frac{p_{\text{mech}}}{p_{\text{in}}} \times 100$$

where $p_{\text{mech}} = T_m \omega_m$
 $p_{\text{in}} = V_a \times I_a$

At 68 Wm.

$$T_m = 72.3982 \quad \omega_m = 219.911$$

$$p_{\text{mech}} = 72.3982 \times 219.911 = 15921.16 \text{ W}$$

$$p_{\text{in}} = 250 \times 74.5 = 18625 \text{ W}$$

$$\% \eta = \frac{15921.6}{18625} \times 100 = 85.48\%$$

(4)

At 80 Nm.

$$T_m = T_L + b \cdot \omega_m$$

$$\omega_m = 1961.29 \text{ rad/s}$$

$$= 205.386 \text{ X}$$

~~$$T_m = 80 + 0.02 \times 1961.29 = 119.225$$~~

~~$$p_{\text{mech}} = 119.225 \times 1961.29 = 233834.80$$~~

$$p_{\text{in}} = V_a \times I_a$$

$$V_a = E_a$$

$$E_a = k \omega_m$$

$$= 250 \times 122.6855 = 30671.375$$

~~$$\% \eta = \frac{233834}{30671.375} \times 100 =$$~~

$$T_m = 80 + 0.02 \times 205.386 = 84.1077 \text{ X}$$

$$p_{\text{mech}} = 84.1077 \times 205.386 = 17274.5482 \text{ X}$$

$$p_{\text{in}} = 250 \times 122.6855 = 30671.375$$

$$\frac{17274.5482 \times 100}{30671.375} = 56.32\%$$

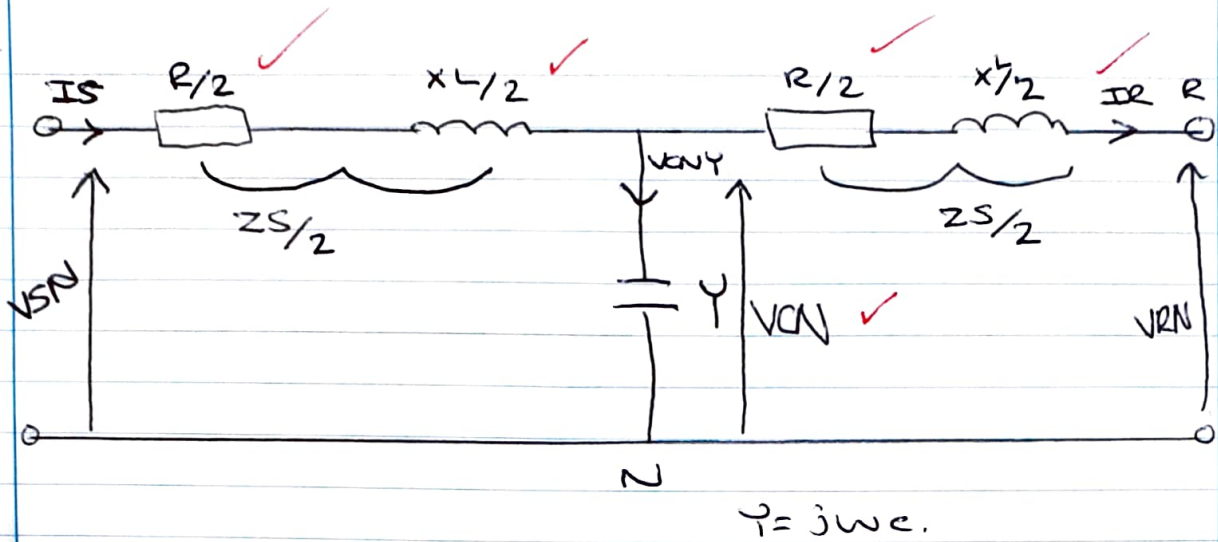
(3)

Correct method,
 2 errors carried
 through

$$85.48 - 56.32 = 29.16\%$$

Not asked for

42



4

✓