



Complete, fold and seal
(see note 2 below)

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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).
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1	Student Number	TAV19852707
2	Title of Examination Paper	Electrical Power
3	Module Code	GOEE5000
4	Date and Time of Examination	19/05/2024 10:00am
5	Examination Venue	main hall Tychoch
6	Seat Number	G2
7	Number of Answer Books handed in	1

List the numbers of the questions you have attempted	Office Use
1	
2	
3	
4	
Q1	29 ✓
Q2	23 ✓
Q3	30 ✓
Q4	2 ✓
Total	84/100

84%

Question One

a)

$$(20 - j15) + (6 + j3) = 26 - j12 = 2$$

$$I = \frac{V}{Z} = \frac{240 \angle 0^\circ}{2}$$

$$26 - j12 \xrightarrow{\text{Pol}} 28.6 \angle -24.8^\circ \Omega \quad \underline{5}$$

$$\text{Power factor} = \cos \theta = \cos(-24.8) = \underline{0.91}$$

b)

$$Z_1 = 65 + j35 \Omega \quad Z_T = Z_{123}$$

$$Z_2 = 0 - j15 \Omega$$

$$Z_3 = 25 + j0 \Omega$$

$$Z_{12} = \frac{(65 + j35)(-j15)}{65 + j20} = \frac{(73.8 \angle 28.3^\circ)(15 \angle -90^\circ)}{68 \angle 17.1^\circ}$$

$$Z_{12} = \frac{1107 \angle -61.7^\circ}{68 \angle 17.1^\circ} = 16.3 \angle -78.8^\circ \xrightarrow{\text{rec}} 3.2 - j16 \Omega$$

$$Z_T = (3.2 - j16 \Omega) + (25 + j0 \Omega) = 28.2 - j16 \Omega \xrightarrow{\text{Pol}} 32.4 \angle -29.6^\circ \quad \underline{15}$$

$$I = \frac{V}{Z_T} = \frac{220 \angle 0^\circ}{32.4 \angle -29.6^\circ} = 6.8 \angle 29.6^\circ \text{ A} \quad \underline{2}$$

$$S = V \times (I)^* = (220 \angle 0^\circ) \times (6.8 \angle -29.6^\circ) = \underline{1496 \angle -29.6^\circ} \text{ VA}$$

$$S = P + jQ \text{ so } 1300.8 - j738.9 \text{ VA units} \quad \underline{5}$$

$$P = \underline{1300.8 \text{ W}}$$

$$Q = \underline{-738.9 \text{ VAR}}$$

Q1

29/30

Q1a

5/5

Q1b

24/25

Question Two

$$a) S_1 = 120 \text{ kVA}$$

$$P_{f1} = 0.65$$

$$V = 220 \text{ V}$$

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

$$P_{f2} = 0.9$$

$$P_{f1} = \cos \theta_1 \quad \text{so} \quad \cos^{-1}(0.65) = \theta_1 = 49.5^\circ$$

$$Q_1 = S_1 \sin(\theta_1) = 120 \text{ kVA} \sin(49.5^\circ) = 91.2 \text{ kVAR}$$

$$P_{f2} = \cos \theta_2 \quad \text{so} \quad \cos^{-1}(0.9) = \theta_2 = 25.8^\circ$$

$$P = S_1 \times \cos \theta = 120 \cos(49.5^\circ) = 77.9 \text{ kW}$$

$$S_2 = \frac{P}{P_{f2}} = \frac{77.9 \text{ kW}}{0.9} = 85.5 \text{ kVA}$$

$$Q_2 = S_2 \sin(\theta_2) = 85.5 \sin(25.8^\circ) = 37.2 \text{ kVAR}$$

$$Q_d = Q_1 - Q_2 = 91.2 - 37.2 = 54 \text{ kVAR}$$

$$X_c = \frac{V^2}{Q_d} = \frac{220^2}{54 \text{ k}} = 0.00407 \Omega$$

$$C = \frac{1}{2\pi f X_c} = \frac{1}{2\pi \times 50 \times 4.07 \times 10^{-3}} = 0.78 \text{ F}$$

error
carried
forward

Q2

23/25

Q2a

18/20

b)

$$i. Z_T = (15 + j2) + (50 + j40) = 65 + j42 \Omega$$

$$65 + j42 \xrightarrow{\text{pol}} 77.4 \angle 32.9^\circ \Omega$$

$$\text{Power factor} = \cos(32.9) = 0.8$$

ii

$$C = \frac{1}{2\pi f X_C} = \frac{1}{2\pi \times 1.5k \times 114} = 9.3 \times 10^{-7} F$$

or

$$0.93 \mu F$$

Q2b5/5

Question Three

a)

$$Z = 10 - j5 \text{ or } 11.2 \angle -26.6^\circ$$

$$\text{i. if } V_{ab} = 220 \angle 0^\circ \text{ V}$$

$$V_{bc} = 220 \angle -120^\circ \text{ V}$$

$$V_{ca} = 220 \angle 120^\circ \text{ V}$$

$$\text{ii. } I_{AB} = \frac{V_{ab}}{Z} = \frac{220 \angle 0^\circ}{11.2 \angle -26.6^\circ} = 19.6 \angle 26.6^\circ \text{ A}$$

so

$$I_{BC} = 19.6 \angle 26.6^\circ - 120^\circ = 19.6 \angle -93.4^\circ \text{ A}$$

$$I_{CA} = 19.6 \angle 26.6^\circ + 120^\circ = 19.6 \angle 146.6^\circ \text{ A}$$

iii.

$$I_a = I_{AB} \times \sqrt{3} \angle -30^\circ = 19.6 \angle 26.6^\circ \times \sqrt{3} \angle -30^\circ = 33.9 \angle -7.4^\circ \text{ A}$$

so

$$I_b = 33.9 \angle -7.4^\circ - 120^\circ = 33.9 \angle -127.4^\circ \text{ A}$$

$$I_c = 33.9 \angle -7.4^\circ + 120^\circ = 33.9 \angle 116.6^\circ \text{ A}$$

Q330/30Q3a15/15

Question Three

b)

$$V_{AB} = 400V \angle 0^\circ$$

so

$$V_{BC} = 400V \angle -120^\circ$$

$$V_{CA} = 400V \angle 120^\circ$$

i.

$$V_{an} = \frac{V_{AB}}{\sqrt{3} \angle 30^\circ} = \frac{400V \angle 0^\circ}{\sqrt{3} \angle 30^\circ} = 230.9 \angle -30^\circ V$$

so

$$V_{bn} = 230.9 \angle -30 - 120 = 230.9 \angle -150^\circ V$$

$$V_{cn} = 230.9 \angle -30 + 120 = 230.9 \angle 90^\circ V$$

ii.

$$Z_Y = 6 + j6 \Omega \text{ or } 8.5 \angle 45^\circ \Omega$$

$$I_a = \frac{V_{an}}{Z_Y} = \frac{230.9 \angle -30^\circ}{8.5 \angle 45^\circ} = 27.2 \angle -75^\circ A$$

so

$$I_b = 27.2 \angle -75^\circ - 120 = 27.2 \angle -195^\circ A$$

$$I_c = 27.2 \angle -75^\circ + 120 = 27.2 \angle 45^\circ A$$

iii.

$$\text{Power factor} = \cos \theta = \cos(45) = 0.71$$

or

$$\text{iv. } P_a = V_{an} I_a \cos \theta = 230.9 \angle -30^\circ \times 27.2 \angle -75^\circ \times \cos(45)$$

$$P_a = 4441 \text{ W}$$

$$P_b = 230.9 \angle -150^\circ \times 27.2 \angle -195^\circ \times \cos(45) = 4441 \text{ W}$$

$$P_c = 4441 \text{ W}$$

$$P_T = 4441 \times 3 = 13,323 \text{ W}$$

Q3b

15/15

a) ~~K0~~

$$K0 = 0.2 \Omega$$

X

$$V = 240V$$

$$I_1 = 3A$$

$$N = 1500 \text{ rev/min} \text{ vs}$$

$$I_2 = 30A$$

$$P_1 = 3 \times 240 = 720W$$

X

$$P_2 = 30 \times 240 = 7200W$$

X

$$E = 0.2 \times 1500 = 300$$

$$R_2 \quad 240 = E + 30 \times 0.2$$

$$240 - (30 \times 0.2) = E = 234$$

$$\frac{234}{0.2} = \omega_2 = 1170 \text{ rev/min}$$

X 0=

b)

$$4:1$$

$$N_1 = 4$$

$$N_2 = 1$$

$$V_1 = 440V$$

$$I_2 = 20A$$

$$P_f = 0.9$$

$$\frac{4}{1} = \frac{440}{V_2}$$

$$\frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{I_2}{I_1}$$

$$V_2 = 440 \frac{1}{4} = 110V$$

$$I_1 = 20 \frac{1}{4} = 5A$$

ii

~~220~~

$$P_2 = V_2 \times I_2 = 110 \times 20 = 2200W \text{ or } 2.2kW$$

X

X 0=

Q4a2/15Q4a0Q4b2/15