higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T540(**E**)(A11)T

NATIONAL CERTIFICATE

ELECTROTECHNICS N5

(8080085)

11 April 2018 (X-Paper)
09:00–12:00

Calculators may be used.

This question paper consists of 6 pages and 2 formula sheets.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ELECTROTECHNICS N5
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Write neatly and legibly.

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QUESTION 1

1.1 Briefly explain what is meant by *armature reaction* in a DC generator. (2)

1.2 Explain why a DC shunt motor needs a starter on constant voltage mains. (3)

1.3 A 35 kW, 400 V, DC shunt motor has an armature resistance of 0,5 ohms. The full-load armature current is 55 A and the motor is developing 80% of the rated torque. Assume flux to be unsaturated.

Find the resistance that should be inserted in series with the armature circuit to obtain a 30% speed reduction. (10)

1.4 A 440 V shunt motor has an armature resistance of 0,8 ohms and a field resistance of 200 ohms.

Determine the back EMF when giving an output of 7,46 kW at 85% efficiency. (5)

[20]

QUESTION 2

2.1 The following ordinates were taken during a half cycle of a symmetrical alternating-current wave. The current varies in a linear manner between successive points:

Phase angle (Degrees)	0	30	60	90	120	150	180
Current (Amperes)	0	10,4	21,4	27	25	11,4	0

Determine without plotting the graph, the following values of the wave:

2.1.1 The mean value (5)

2.1.2 The RMS value (3)

2.1.3 The form factor (1)

2.2 The voltage across a circuit element is $V(t) = 450 \sin (628\ t + 60^{\circ})$ volts and the current flowing in this element is $I(t) = 45 \sin (628\ t + 60^{\circ})$ amperes.

Determine:

2.2.1 The nature and magnitude of this element

2.2.2 The time period of the waveform

(2 × 2) (4)

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2.3 A metal-filament lamp, rated at 1 000 W, 120 V, is connected in series with a capacitor. This circuit is connected across a 220 V, 60 Hz supply.

Calculate:

2.3.1 The capacitance required (5)

2.3.2 The phase angle between the current and supply voltage (2)
[20]

QUESTION 3

3.1 State TWO factors that must be considered when connecting two transformers in parallel. (2)

3.2 A 11 kVA, 2 100/220 V, single-phase transformer has a percentage impedance of (2 + j6) per cent.

Calculate:

3.2.1 The equivalent resistance and leakage reactance referred to the primary side of the transformer (5)

3.2.2 The terminal voltage on full load at a power factor of 0,8 lagging (5)

3.2.3 The voltage that should be applied to the primary to circulate a full-load current with the secondary short-circuited (2)

3.3 Two single-phase transformers with equal voltage ratios operate in parallel and supply a load of 4 000 kVA at 0,8 power factor lagging. The equivalent impedances of the transformers referred to the secondary side are 0,35 ohm < 65° and 0,65 ohm < 80° respectively.

Calculate the kVA output and power factor of each transformer. (6)
[20]

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QUESTION 4

4.1 Calculate the inductance and capacitance per phase of 10 km of a three-phase overhead transmission line with solid copper conductors of 1 cm in diameter and symmetrically spaced at 70 cm between centres. Take the resistivity of copper conductors as 1,71 micro-ohm centimetre. (10)

4.2 Three identical coils are connected in star across a three-phase, 400 V, 50 Hz supply. The readings on two watt meters connected to measure the total power absorbed, are 2,85 kW and 1,9 kW respectively.

Determine:

4.2.1 The total power (2)

4.2.2 The power factor (4)

4.2.3 The line current (2)

4.3 A three-phase transmission line has an equilateral conductor spacing of 4 m and a conductor diameter of 25 mm.

Calculate the inductance per phase of a 80 km line. (2)
[20]

QUESTION 5

5.1 Name TWO methods used for finding the slip of the induction motor. (2)

5.2 Is a single-phase induction motor self-starting? Give ONE reason for the answer. (2)

5.3 Determine the number of stator conductors per slot for a three-phase, 50 Hz alternator, if the winding is star-connected and has to give a line voltage of 15 kV when the machine is on an open circuit. The flux per pole is 0,15 Wb. Assume full-pitch coils and the stator to have three slots per pole per phase. The speed is 300 r/min and the distribution factor is 0,96. (6)

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5.4 Two similar three-phase star-connected alternators are connected in parallel. Each machine has a synchronous reactance of 6,5 ohms per phase with a negligible resistance. The machines are adjusted to be in exact phase opposition relative to each other and the excitation of one alternator is adjusted to give an open-circuit voltage of 3 600 V phase.

With reference to a phasor diagram and for a circulating current of 61,53 A, calculate:

5.4.1 The open-circuit voltage of the one machine assuming it is less than that of the other (4)

5.4.2 The terminal voltage (3)

5.5 A three-phase induction motor is wound for 6 poles and is supplied from a 50 Hz system.

Calculate the speed of the rotor when the slip is 5%. (3)

[20]

TOTAL: 100

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ELECTROTECHNICS N5

FORMULA SHEETS

Armature ampere-turns/pole $= \frac{1}{2} \cdot \frac{I_a}{C} \cdot \frac{Z}{2P}$

$E = V \pm I_a R_a$

$E = \frac{2pNZ\Phi}{60c}$

$T = 0{,}318 \frac{I_a}{c} ZP\Phi$

$k = n\sqrt{\frac{R_1}{r_m}}$

$r_1 = R_1 \left[\frac{k-1}{k}\right]$

$r_1 = R_s \frac{1-y}{1-y^m}$

$R_1 = bR_1 (k-1) \times \frac{1-b^n}{1-b} + r_m$

$y = \frac{I_2}{I_1}$

$r_1 = bR_1 (k-1)$

$\frac{E_1}{E_2} = \frac{K\Phi_1 N_1}{K\Phi_2 N_2}$

$\frac{T_1}{T_2} = \frac{K\Phi_1 I_{a1}}{K\Phi_2 I_{a2}}$

$I_{ave/gem} = \frac{i_1 + i_2 + i_3 + \ldots i_n}{n}$

$I_{rms/wgk} = \sqrt{\frac{i_1^2 + i_2^2 + i_3^2 + \ldots + i_n^2}{n}}$

$f = \frac{1}{2\pi\sqrt{LC}}$

$f = \frac{1}{2\pi L}\sqrt{\frac{L}{C} - R^2}$

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$$P = \sqrt{3} I_L V_L \, Cos \, \phi$$

$$P_1 = V_L I_L \, Cos \, (30 - \phi)$$

$$P_2 = V_L I_L \, Cos \, (30 + \phi)$$

$$\tan \phi = \frac{\sqrt{3} \, (P_2 - P_1)}{(P_2 + P_1)}$$

% Voltage regulation

$$= I_1 \frac{(R_e \, Cos\phi \pm X_e \, Sin\phi)}{v_1} \times \frac{100}{1}$$

$$Z_e = \sqrt{R_e^2 + X_e^2}$$

$$\%Z_e = \frac{I \, Z_e}{V} \times \frac{100}{1}$$

$$S_1 = S \frac{Z_2}{Z_1 + Z_2}$$

$$E = 2{,}222 \; k_d k_p \; Z\Phi f$$

$$I_r = \frac{E_r}{Z_r}$$

$$E_o = V_p \frac{Z_r}{Z_s}$$

$$Cos\phi_r = \frac{R}{Z_r}$$

$$s = \frac{2\pi T (n_s - n_r)}{2\pi T \, n_s}$$

$$L = 0{,}05 + 0{,}2 \, Lin \, \frac{d}{r}$$

$$C = \frac{1}{36 Lin \, \frac{d - r}{r}}$$

$$C = \frac{1}{18 Lin \, \frac{de}{r}}$$

% Regulation

$$= \frac{V_s - V_R}{V_R} \times \frac{100}{1}$$

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