higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T540**(E)**(A6)T

NATIONAL CERTIFICATE

ELECTROTECHNICS N5

(8080085)

6 August 2018 (X-Paper)
09:00–12:00

Calculators may be used.

This question paper consists of 5 pages and a formula sheet of 2 pages.

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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 Explain the term *pole pitch* as it applies to electrical machines. (1)

1.2 Differentiate between the function of *commutating poles* and *compensating windings* in a DC machine. (1 + 1) (2)

1.3 How can the number of parallel paths in lap-wound armature be increased? (1)

1.4 A four-pole DC motor has a wave-connected armature with 860 conductors. The brushes have been displaced through three angular degrees from the geometrical neutral axis.

If the armature current is 150 A, calculate:

1.4.1 The demagnetising and cross-magnetising ampere turns per pole (5)

1.4.2 The additional field current required to neutralise this demagnetisation if the field winding has 1 100 turns per pole (2)

1.5 A six-pole, lap-wound, 350 V, shunt-excited DC machine draws an armature current of 7,5 A at no load and runs at 1 300 r/min. When loaded, the motor draws an armature current of 70 A from the supply and runs at 1 300 r/min. The resistance of the armature circuit is 0,6 ohms and there are 1 100 armature conductors.

Calculate the following for loaded conditions:

1.5.1 The generated EMF (2)

1.5.2 The useful flux per pole (4)

1.5.3 The useful torque developed by the machine in newton meter (Nm) (3)

[20]

QUESTION 2

2.1 A resonant circuit consists of a coil of inductance of 430 µH and a resistance of 35 ohms in parallel with a variable capacitor. This circuit is then connected in series with a resistor of 8 400 ohms. The supply across the circuit is 80 V with a frequency of 1,8 MHz.

Calculate:

2.1.1 The impedance of the parallel branch (6)

2.1.2 The voltage drops across the coil (3)

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2.2 An impedance (Z_1) of 5 + j4 ohms is connected in parallel with an unknown impedance (Z_2). This circuit is then connected in series with another impedance (Z_3) comprising a resistance of 2 ohms in series with a capacitive reactance of 4 ohms. The complete circuit is then connected to a 100 volt, 50 hertz supply. The total current flowing through the circuit is 24,149 amperes at a power factor of 0,724 leading.

Determine:

2.2.1 The current flowing through the unknown circuit (6)

2.2.2 The power factor of the unknown circuit (1)

2.2.3 The resistance and reactance of the unknown circuit (4)

[20]

QUESTION 3

3.1 Give TWO reasons why some transformers are housed in tightly fitted tanks filled with special oil. (2)

3.2 The primary and secondary windings of a 25 kVA, 5 800/220 volt transformer have resistances of 11 ohms and 0,016 ohms respectively. The total reactance of the transformer referred to the primary side is 24 ohms.

Calculate the percentage regulation at a power factor of 0,8 lagging. (6)

3.3 Two single-phase transformers of equal voltage ratios with the following ratings and impedances are connected in parallel to supply a load of 1 100 kW at a power of 0,85 lagging:

Transformer A	1 400 kVA	2 Ω resistance	8 Ω reactance
Transformer B	2 000 kVA	1,4 Ω resistance	7 Ω reactance

Calculate the kVA in each transformer as well as its power factor. (12)

[20]

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QUESTION 4

4.1 Define *voltage regulation of the transmission line*. (2)

4.2 Each phase of a three-phase balanced load consists of a coil with a resistance of 10 ohms and inductance of 0,02 henry in parallel with a capacitor of 31,8 microfarad. The supply voltage is 415 volts, 50 hertz.

Calculate the line current when connected in star. (8)

4.3 A load of 2 500 kVA at 11 kV and a power factor of 0,8 lagging is supplied by a three-phase transmission line having a resistance of 3 ohms per phase and an inductive reactance of 6 ohms per phase.

Determine:

4.3.1 The percentage regulation (7)

4.3.2 The efficiency of the line (3)

[20]

QUESTION 5

5.1 Explain why an induction motor cannot develop torque when running at synchronous speed. (3)

5.2 A three-phase slip-ring induction motor gives a reading of 55 volts across the slip rings on open circuit when at rest with normal stator voltage applied. The rotor is star-connected and has impedance of 0,7 + j5 ohms per phase.

Calculate the rotor current when the machine is:

5.2.1 At standstill with the slip rings joined to a star-connected starter with phase impedance of 4 + j3 ohms (3)

5.2.2 Running normally with a 5% slip (4)

5.3 A three-phase star-connected alternator feeds a 40 kW, 2 kV, delta-connected induction motor with an efficiency of 80% and a full-load power factor of 0,87.

Calculate:

5.3.1 The value of the current in the alternator and motor windings (4)

5.3.2 The kVA output of the alternator (2)

5.4 Explain the terms *distribution factor* and *pitch factor* with reference to alternators. (2 + 2) (4)

[20]

TOTAL: 100

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FORMULA SHEET

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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