higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ELECTROTECHNICS N5

(8080085)

28 November 2023 (X-paper)
09:00–12:00

Nonprogrammable 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. Use only a black or blue pen.
5. Write neatly and legibly.

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QUESTION 1

1.1 What is meant by *armature reaction* as applicable to DC machines? (1)

1.2 A six-pole DC machine has a wave-connected armature with 960 conductors. The brushes are moved backwards by 4º. Calculate the following:

1.2.1 The demagnetising and cross magnetising ampere turns per pole (4)

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

1.3 A DC shunt generator delivers 8 kW at 300 V when driven at 1 300 r/min. The shunt resistance is 300 Ω and the armature resistance is 0,6 Ω. The iron, friction and windage losses are 500 W. Determine the required torque to drive the generator. (6)

1.4 Name TWO causes of sparking at the brushes on DC machines. (2)

1.5 An eight-pole DC motor in draws an armature current of 100 A at 550 V. The resistance of the armature circuit is 0,4 Ω, and the armature has 900 wave-connected conductors. The useful flux is 0,07 Wb per pole.

Calculate the speed of the motor in revolutions per minute. (5)
[20]

QUESTION 2

2.1 Circuit A and circuit B are connected in parallel across a 230-V, 50-Hz supply. Circuit A consists of a 15-Ω resistor and a 300-µF capacitor connected in series. Circuit B consists of coil having inductive reactance and resistance. The total current drawn by circuit A is 13 A at a power factor of 1. Calculate the following for circuit B:

2.1.1 The current flow (6)

2.1.2 The power factor (2)

2.1.3 The impedance (2)

2.1.4 The reactance (2)

2.1.5 The resistance (1)

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2.2 Calculate the impedance at resonance of a circuit consisting of a coil with inductance of 0,6 mH and an effective resistance of 20 Ω in parallel with a 0,0003-µF capacitor. (2)

2.3 List THREE methods to improve power factor. (3)

2.4 State TWO characteristics of parallel circuits that are at resonance. (2)
[20]

QUESTION 3

3.1 Explain the difference between *useful flux* and *leakage flux.* (2)

3.2 A 15-kVA, 3,300/600-V single-phase transformer, operating at no load, has resistances and leakage reactances as follows:
Primary winding: Resistance 9 Ω, reactance 16 Ω
Secondary winding: Resistance 0,6 Ω, reactance 0,9 Ω

Calculate the approximate value of the secondary voltage at full load, with a power factor of 0,8 lagging, when the primary voltage is 3 300 V. (8)

3.3 A 1 000-kVA, 33-kV single-phase transformer with a resistance of 2% and a reactance of 6% is connected in parallel with a 1 400-kVA, 11-kV single-phase transformer with a resistance of 3% and a reactance of 7%. For this condition, calculate the loading factor and the power factor of each transformer when the total connected single-phase load is 2 000 kVA at a power factor of 0,85 lagging. Also state which one of the transformers overloaded. (8)

3.4 How are iron losses in a transformer effected when the supply frequency to the transformer is altered? (2)
[20]

QUESTION 4

4.1 Explain the term *distribution factor.* (2)

4.2 Determine the number of stator conductors per slot for a three-phase 50-Hz alternator if the winding is star-connected and generates a line voltage of 33 kV at 1 000 r/min during open circuit. Take the flux per pole as 0,4 Wb and the distribution factor as 0,96. The coils are full pitched and the stator has three slots per pole per phase. (8)

4.3 A four-pole, three-phase, 50-Hz induction motor has a slip of 4% when fully loaded. Calculate the full-load speed. (4)

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4.4 The stator of a three-phase, six-pole, 50-Hz induction motor is 88% efficient when the total input power is 430 kW. For rotor losses of 13 kW, calculate the following:

4.4.1 The stator output

4.4.2 The mechanical power developed

4.4.3 The total torque developed

(3 × 2) (6)

QUESTION 5

5.1 Calculate the resistance, inductance and capacitance of a 15-km single-phase overhead transmission line with solid copper conductors of 19 mm diameter and spaced 1 metre between centres.

Assume the resistivity of copper is 0,0173 μΩm and ignore the skin effect. (8)

5.2 A 500-V, three-phase, star-connected motor has an output of 70 kW and operates at a power factor of 0,85 with an efficiency of 90%.

Calculate the reading on each of the two wattmeters connected to measure the total power input to the motor. Take the phase sequence as R-Y-B-R. (12)

[20]

TOTAL: 100

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ELECTROTECHNICS N5

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

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

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