higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ELECTROTECHNICS N5

(8080085)

2 August 2021 (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.

132Q1G2102

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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. Start each question on a new page.
5. Only use a black or blue pen.
6. Write neatly and legibly.

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QUESTION 1

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

1.2 A series-wound DC motor runs at 900 r/min when taking 30 A at 230 V. The total resistance of the armature and field circuit is 0,8 Ω.

Calculate the value of the additional resistance required in series with the machine to reduce the speed to 600 r/min if the gross torque is constant. (6)

1.3 Draw the magnetic characteristic curves of the following compound-wound generators:

- Over-compounded
- Under-compounded
- Level-compounded (6)

1.4 A DC shunt generator delivers 5 kW at 250 V when driven at 1 500 r/min. The shunt circuit resistance is 250 Ω and the armature circuit resistance is 0,4 Ω. The iron, friction and windage loss is 250 W.

Determine the torque required to drive the generator. (5)

[20]

QUESTION 2

2.1 A coil of 30 Ω resistance and 0,07 H is connected in parallel with a circuit consisting of a 135-microfarad capacitor in series with a 20-ohm resistor. The supply voltage is 290 V, 50 Hz.

Calculate the following:

2.1.1 The total current (6)

2.1.2 The current in each branch (4)

2.2 Circuit A consists of a 6,8-ohm resistor and a 170-microfarad capacitor connected in series. Circuit B consists of a resistor and an inductive reactance connected in series. Both circuits A and B are then connected in parallel across a supply of 240 V, 50 Hz. The total current taken by the parallel combination is 15 A at unity power factor.

Calculate the following for Circuit B:

2.2.1 The current (4)

2.2.2 The impedance (2)

2.2.3 The power factor (1)

2.3 State any THREE characteristics of a resonant series circuit. (3)

[20]

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QUESTION 3

3.1 List THREE types of transformer losses. (3)

3.2 A single-phase transformer has a supply voltage of 230 V. It has an equivalent resistance of 0,3 Ω and an equivalent leakage reactance of 0,75 Ω referred to the primary side. The secondary side is connected to a coil with a resistance of 25 Ω and a reactance of 32,5 Ω. The secondary winding has three times as many turns as the primary winding.

Calculate the secondary terminal voltage. (9)

3.3 A single-phase transformer of 15 kVA, 1 800/180 V, has a percentage impedance of 4 + j6 percent.

Calculate the following:

3.3.1 The equivalent resistance and leakage reactance (6)

3.3.2 The per unit voltage regulation at a power factor of 0,8 lagging (2)

[20]

QUESTION 4

4.1 Draw a circuit diagram to show how a single wattmeter can be used to measure the total power drawn by a balanced star-connected load. (3)

4.2 A three-phase induction motor develops 28 kW when running at 86% efficiency and a power factor of 0,86 lagging.

Calculate the readings on each wattmeter connected to read the input power. (7)

4.3 A load of 2,8 MVA at 33 kV and power factor of 0,86 lagging is supplied by a single-phase transmission line that has a resistance of 3,6 Ω and a reactance of 7,5 Ω per conductor.

Calculate the percentage regulation. (6)

4.4 Calculate the capacitance per phase of a 100 km, three-phase line if the conductors have a flat regular spacing of 1 m between adjacent conductors with transpositions. The diameter of a conductor is 20 mm. (4)

[20]

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QUESTION 5

5.1 Briefly explain the *distribution factor*. (2)

5.2 Explain why slip is necessary for an induction motor to develop torque. (2)

5.3 A three-phase, four-pole star-connected alternator delivers line voltage of 380 V in open circuit, running at a speed of 1 350 r/min. There are four conductors per slot and six slots per pole per phase. The winding has a pitch factor of 0,866 and a distribution factor of 0,97 and assumes a sine wave form.

Calculate the following:

5.3.1 The frequency (2)

5.3.2 The number of turns per phase (3)

5.3.3 The useful flux per pole (3)

5.4 A three-phase, 50-Hz induction motor has six poles and runs at a speed of 900 r/min when the total torque developed by the rotor is 140 N·m.

Calculate the following:

5.4.1 The total power input to the rotor (4)

5.4.2 The rotor copper loss in watts (4)
[20]

TOTAL: 100

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ELECTROTECHNICS N5

FORMULA SHEET

Armature ampere-turns/pole
Ankerampèrewindings/pool

$$= \frac{1}{2} \cdot \frac{I_a}{C} \cdot \frac{Z}{2P}$$

$$E = V \pm I_a R_a$$

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

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

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

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

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

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

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

$$r_1 = bR_1 \ (k-1)$$

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

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

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

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

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

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

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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
% Spanningsreëling

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

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

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

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

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

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

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

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

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

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

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

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

% Regulation
% Regulering

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

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