higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ELECTROTECHNICS N5

(8080085)

21 April 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.

280Q1A2121

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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 Briefly explain the back EMF of a DC motor. (3)

1.2 A 35 kW, 450 V, DC shunt motor has an armature resistance of 0,42 Ω. The full-load armature current is 48 A.

Calculate the resistance that should be inserted or connected in series with the armature circuit to obtain a 25% speed reduction when the motor is developing 78% of the rated torque. (10)

1.3 A 250 V, 54 kW shunt generator has 800 turns on each pole of its field winding. At no-load a current of 3,8 A in the field winding produces a terminal voltage of 250 V, but at full-load the shunt current has to be increased to 4,8 A for the same terminal voltage at the same speed.

Calculate the number of series field turns per pole required for level compounding. (7)

[20]

QUESTION 2

2.1 Circuit A and circuit B are connected in parallel to a 220 V, 60 Hz supply. The total power absorbed by the combination is 4 400 watts at the power factor of 0,87 lagging.

Circuit A consists of a 4,8 Ω resistor and a 210-microfarad capacitor connected in series. Circuit B consists of a resistor and an inductive reactance connected in series.

Calculate the following for circuit B:

2.1.1 The current (5)

2.1.2 The impedance (1)

2.2 The impedance (Z_1) of 4 – j3 Ω is connected in parallel with an impedance (Z_2) of 5 + j7 Ω. This parallel combination is connected in series with an impedance (Z_3) of 3 + j4 Ω. The combination of parallel and series branches is then connected in parallel with the impedance (Z_4) of 5 + j6 Ω. The current of
12 + j0 A is flowing through the impedance (Z_1) branch.

Calculate the total current of the circuit. (14)

[20]

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QUESTION 3

3.1 State FOUR conditions to operate transformers in parallel. (4)

3.2 A 12 kVA, 5:1 turns ratio, single-phase transformer operating at no-load has a primary winding with a resistance of 4 Ω and a reactance of 8 Ω. It also has a secondary winding with a resistance of 0,3 Ω and a reactance of 0,43 Ω.

Determine the following:

3.2.1 The value of the secondary terminal voltage on full load, with a power factor of 0,8 lagging when the primary supply voltage is 3 000 V (8)

3.2.2 The value of the secondary terminal voltage on full load, with a power factor of 0,8 leading when the primary voltage supply is 3 000 V (4)

3.3 A three-phase transformer has 420 turns on the primary winding and 30 turns on the secondary winding. The supply voltage is 3 300 V.

Calculate the secondary line voltage when the transformer is connected in:

3.3.1 Star-delta

3.3.2 Delta-star

(2 × 2) (4)

[20]

QUESTION 4

4.1 A three-phase induction motor develops 32 kW when running at 88 percent efficiency at a power factor of 0,7 lagging.

Calculate the readings on each of the two wattmeters connected to indicate the input power. (8)

4.2 A three-phase transmission line supplies a 0,55 MW star-connected load with a power factor of 0,8 lagging, at a line voltage of 11 kV. The line has a resistance of 25 Ω per phase and an inductive reactance of 45 Ω per phase.

Calculate the following:

4.2.1 The voltage at the sending end (7)

4.2.2 The percentage regulation (2)

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4.3 Calculate the capacitance per phase of a 65 km, three-phase transmission line having an equilateral conductor spacing of 3 m and a conductor diameter of 25 mm (3)

[20]

QUESTION 5

5.1 State TWO conditions to be satisfied when connecting alternators in parallel. (2)

5.2 Briefly explain the term hunting with reference to synchronous motors. (2)

5.3 A three-phase, 50 Hz, eight-pole induction motor has a slip of 4 percent when the output is 30 kW. The frictional loss is 280 W.

Calculate the following:

5.3.1 The rotor speed (3)

5.3.2 The rotor copper loss (4)

5.4 Two similar, three-phase, star-connected eight-pole alternators are connected in parallel. Each machine has a synchronous impedance of 0,35 + j5 Ω per phase and is excited to generate an EMF of 1 980 V per phase. The machines have a phase displacement of 20 angular degrees relative to each other.

Calculate the following:

5.4.1 The circulating current (5)

5.4.2 The terminal voltage (2)

5.4.3 The power supplied from one machine to the other. Assume that there is no external load. (2)

[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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