higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ELECTROTECHNICS N5

(8080085)

22 November 2022 (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. Start each section on a new page.
5. Use only a black or a blue pen.
6. Write neatly and legibly.

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QUESTION 1

1.1 Name two characteristics of DC machines. (2)

1.2 Can a series motor be started without some mechanical load? Substantiate your answer. (2)

1.3 Explain the term, *commutating plane.* (1)

1.4 The resistance of the armature current of a 250 V shunt motor is 0,2 Ωand its full-load speed is 1 000 r/min.

Calculate:

1.4.1 The resistance required in series with the armature to reduce the speed with full-load torque to 800 r/min. The full-load armature current is 50 A. (5)

1.4.2 What speed will the motor run if the load torque is halved? Neglect the effect of armature reaction. (5)

1.5 A 450 kW, 380 V, six-pole DC generator has a lap connected winding with 180 armature conductors. Calculate the number of turns per pole required for the commutating pole, assuming that the compole ampere turns per pole to be about 1,3 times the armature ampere turns per pole and the brushes to be in the geometric neutral axis. (5)
[20]

QUESTION 2

2.1 The voltage applied to a single element load is
$v(t) = 84{,}86 \sin (1\,000t + 45)$ V.
The resulting current flow is $i(t) + 14{,}14 \sin (1\,000t – 45)$ A.

Calculate the nature and magnitude of the element. (5)

2.2 An impedance $Z1 = (2 – j1)\ \Omega$ is connected in parallel with another impedance $Z2 = (3 – j5)\ \Omega$. This circuit is connected in series with another impedance $Z3 = (1 + j2)\ \Omega$. The combination is then connected in parallel to an impedance of $Z4 = (3 + j4)\ \Omega$. Z2 is connected across points AB. Z4 is connected across points CD and Z3 across points AC. I1 flowing through Z1 is 10 A. I2 flowing through Z2, I3 through Z3 and I4 through Z4. The circuit is then connected to a supply across Z4.

2.2.1 Draw the circuit diagram clearly showing all its elements (impedances and supply source). (2)

2.22 Calculate the input supply voltage and current. (13)
[20]

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QUESTION 3

3.1 Each phase of a three-phase balanced load consists of a coil, of resistance of 10 Ω and inductance of 0,02 H in parallel with a capacitor of 31,8 µF. The supply voltage is 415 V, 50 Hz. Calculate the line current when connected in star. (5)

3.2 A 500 kVA, 33/3,3 kV single-phase transformer with a resistance voltage drop of 1,5% and the reactance voltage drop of 6% is connected in parallel with a 1 000 kVA, 33/3,3 kV single-phase transformer with a resistance voltage drop of 1% and a reactance voltage drop of 6,2%.

Calculate the kVA loading and operating power factor of each transformer when the total load is 1 200 kVA at a power factor of 0,8 lagging. (7)

3.3 The primary and secondary windings of a 30 kVA, 6 000/230 V transformer has a resistance of 12 Ω and 0,018 Ω respectively. The total resistance reactance of the transformer referred to the primary is 26 Ω.

Calculate the percentage regulation of a transformer when supplying full-load current at a power factor of 0,8 lagging. (5)

3.4 State the THREE most essential requirements that must be adhered to before transformers are connected in parallel. (3)
[20]

QUESTION 4

4.1 The two-wattmeter method is applied to a three-phase three-wire 120 V system, with the meters connected to lines R and B, WR = 820 W and WB = –480 W. Find the impedance of the balanced delta connected load. (5)

4.2 A three-phase induction motor develops 20 kW when running at 90% efficiency, at a power factor of 0,45 lagging.

Calculate the readings on each of the two watt meters connected to read the input power. (5)

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 with a resistance of 3 Ω per phase and a reactance of 6 Ω per phase.

Determine the following:

4.3.1 Percentage regulation of the line (7)

4.3.2 Efficiency of the line (3)
[20]

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QUESTION 5

5.1 As the load on the alternator is varied, its terminal voltage is also found to vary. Mention TWO reasons for that terminal voltage variation. (2)

5.2 Give THREE conditions for proper synchronisation of alternators. (3)

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

Calculate the rotor current when the machine is

5.3.1 at a standstill with the slip-rings joined to a star-connected starter with a phase impedance of (4 +j3) Ω (3)

5.3.2 running normally with a 5% slip (2)

5.4 Find the number of stator conductors per slot for a three-phase 50 Hz alternator if the winding is star-connected and should provide a line voltage of 15 kV when the machine is on the open circuit. The flux per pole is 0,15 Webber. Assume full-pitch coils and the stator to have three slots per pole per phase. The speed is 250 r/min and the distribution factor is 0,95. (5)

5.5 Two similar, three-phase star-connected alternators are connected in parallel. Each machine has a synchronous reactance of 7,5 Ω per phase and 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 3 800 V per phase. With reference to a phasor diagram and for a circulating current of 64 A,

calculate the following:

5.5.1 Open circuit voltage of the other machine, assuming it is less than that of the first machine. (3)

5.5.2 Terminal line voltage (2)

[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

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

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