higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ELECTROTECHNICS N5

(8080085)

26 November 2024 (X-paper)
09:00–12:00

Non-programmable calculators may be used.

This question paper consists of 5 pages and a formula sheet of 5 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 State the FOUR applications of a series-wound motor. (4)

1.2 Briefly explain the practical application of lap and wave windings regarding DC machines. (2)

1.3 At a sinter production plant at Saldanha Steel, Saldanha Bay, the resistance of an armature circuit of a 260 V shunt motor is 0,25 ohms and its full-load speed is 1 100 revolutions per minute.

1.3.1 Calculate the resistance required in series with the armature to reduce the speed with full-load torque to 900 revolutions per minute. The full load armature current being 60 A. (5)

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

1.4 A 340 V, 115 kW shunt generator has 1 800 turns on each pole of its field winding. At no-load a current of 5,5 A in the field winding produces a terminal voltage of 340 V but at full load the shunt current has to be increased to 7 A for the same terminal voltage at the same speed.

Calculate the number of series field turns per pole required for level compounding. (4)

[20]

QUESTION 2

2.1 A constant voltage at a frequency of 0,75 MHz is applied across a circuit consisting of an inductor in series with a variable capacitor.

The current is at maximum value when the capacitor is adjusted to 360 pF. The current is 0,707 of its maximum value when the capacitance is reduced to 340 pF.

Find the inductance and resistance of the inductor. (10)

2.2 At an Eskom electricity (power) generation plant at Camden, Ermelo, a resonant circuit comprising of a coil with inductance of 350 µH and a resistance of 30 ohms in parallel with a variable capacitor, is connected in series with a resistor of 6 500 ohms. The supply across this circuit is 80 V with a frequency of 2,2 MHz.

Calculate the following:

2.2.1 The value of the capacitor at resonance (5)

2.2.2 The impedance of the parallel circuit (2)

2.2.3 The current in each branch (3)

[20]

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QUESTION 3

3.1 A three-phase transformer supplying a residential dwelling in Protea Glen, Soweto (Gauteng), has 510 turns on the primary and 60 turns on the secondary winding. The supply voltage is 3 400 V.

Calculate the secondary line voltage on no-load when the transformer is connected in:

3.1.1 Star-delta (3)

3.1.2 Delta-star (3)

3.2 A 245 kVA transformer has 450 turns on the primary and 130 turns on the secondary winding. The primary and secondary resistances are 0,8 ohms and 0,06 ohms and the leakage reactances are 1,7 ohms and 0,07 ohms respectively. The supply voltage is 2 650 V.

Calculate the following:

3.2.1 The equivalent impedance referred to the primary circuit. (3)

3.2.2 Voltage regulation and secondary terminal voltage on full-load for power factor of 0,9 lagging, as well as for power factor of 0,9 leading. (11)

[20]

QUESTION 4

4.1 A three-phase transmission line supplies an 820 kW star-connected load with a power factor of 0,8 lagging, at a line voltage of 33 kV. The line has a resistance of 40 ohms per phase and an inductive reactance of 70 ohms per phase.

Calculate the voltage at the sending end and the percentage regulation. (8)

4.2 The two-wattmeter method is applied to a three-phase wire, 150 V system. With the meters connected to lines R and B, WR =1 200 W and WB = 650 W.

Find the impedance of the balanced delta-connected load. (6)

4.3 The load taken by a three-phase induction motor was measured according to the two-wattmeter method, and the readings were 920 W and 295 W respectively.

Calculate the power taken by the motor and the power factor. (4)

4.4 Define the term, *voltage regulation*, of a transmission line. (2)

[20]

QUESTION 5

5.1 A three-phase induction motor has 4 poles and is supplied from a 50 Hz supply.

Calculate the following:

5.1.1 The synchronous speed (3)

5.1.2 The rotor speed when the slip is 7,5% (3)

5.1.3 The rotor frequency (2)

5.2 Two similar single-phase, alternators are connected in parallel. Each machine has a synchronous impedance of 0,8 + j 9,5 ohms and when excited it generates an open circuit EMF of 2 100 volts. The machines has a phase displacement of 40 electrical degrees relative to each other.

Calculate the following:

5.2.1 The circulating current (6)

5.2.2 The terminal voltage (2)

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

5.3 Define the term, *slip*, with regard to induction motors. (2)

[20]

TOTAL: 100

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ELECTROTECHNICS N5

FORMULA SHEET

Armature ampere-turns/pole $= \frac{1}{2} \cdot \frac{I_a}{C} \cdot \frac{Z}{2P}$

Demag-ampere-turns/pole $= \frac{1}{2} \cdot \frac{I_a}{C} \cdot \frac{Z}{2P} \text{x} \frac{4\theta}{360°}$

Crossmag-ampere-turns/pole $= \frac{1}{2} \cdot \frac{I_a}{C} \cdot \frac{Z}{2P} \text{x}(1-\frac{4\theta}{360°})$

DC machines

$E = V \pm I_a R_a$

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

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

DC motor starters

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

$(n-1)\log(\frac{I_1}{I_2}) = \log(\frac{R_1}{R_a})$

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

$R_s = \frac{V}{I_1} - R_a$

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

$\frac{1}{Y} = (\frac{V}{IR})\ to\ the\ exponent\ \ (\frac{1}{m})$

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

$Y = \frac{I_2}{I_1} = \frac{r_2}{r_1} = \frac{r_3}{r_2}$ etc

$r_1 = bR_1\ (k-1)$

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Speed Control of DC Motors

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

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

Alternating Current (AC) Theory

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

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

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

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

$$\bar{I}_R = \frac{V \angle 0°}{Z_{RN} \angle \phi_1}$$

$$\bar{I}_y = \frac{V \angle -120°}{Z_{YN} \angle \phi_2}$$

$$\bar{I}_B = \frac{V \angle 120°}{Z_{BN} \angle \phi_3}$$

$$\bar{I}_N = \bar{I}_R + \bar{I}_B + \bar{I}_Y$$

$$\bar{I}_{RY} = \frac{\bar{V}_{RY}}{\bar{Z}_{RY}} \quad \bar{I}_R = \bar{I}_{RY} - \bar{I}_{BR}$$

$$\bar{I}_{YB} = \frac{\bar{V}_{YB}}{\bar{Z}_{YB}} \quad \bar{I}_Y = \bar{I}_{YB} - \bar{I}_{RY}$$

$$\bar{I}_{BR} = \frac{\bar{V}_{BR}}{\bar{Z}_{BR}} \quad \bar{I}_B = \bar{I}_{BR} - \bar{I}_{YB}$$

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Measurement of AC Power

$$S = IpV_p = KVA$$

$$P = IpVp\ Cos\ \phi$$

$$S = \sqrt{3}\ V_L\ I_L = KVA$$

$$P = 3\ IpVp\ Cos\ \phi$$

$$P = \sqrt{}\ 3I_L V_L\ Cos\ \phi$$

$$P_1 = V_L I_L\ Cos\ (30 + \phi)$$

$$P_2 = V_L I_L\ Cos\ (30 - \phi)$$

$$\tan\phi = \frac{\sqrt{3}\ (P_2 - P_1)}{(P_2 + P_1)}$$

Transformers

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

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

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

$$\%\ R = \frac{I\ \text{Re}}{V}$$

$$\%\ X = \frac{I\ Xe}{V}$$

$$\%\ Z_e = \%\ R_e + j\ \%\ X_e$$

$$V_{SC} = I\ Z_e$$

$$P_{SC} = I^2\ R_e$$

$$Cos\ \phi_e = \frac{P_{SC}}{I_1\ V_{SC}}$$

$$Reg = \frac{V_{SC}\ Cos\ (\phi_e \pm \phi_2)}{V}$$

$$Reg = \frac{I\ Z\ Cos\ (\phi_e \pm \phi_2)}{V}$$

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

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

$$\mathrm{E_R} = \mathrm{E_A} \angle 0^\circ + \mathrm{E_B} \angle (180^\circ - \alpha)$$

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Alternating Current (AC) Machines

$I_c = \frac{ER}{2Z}$

Terminal Voltage = $E_A \angle 0 - \frac{1}{2} E_R$

$$n = \frac{f}{p}$$

$$R_2 = SXo$$

Rotor copper loss = S rotor input

$$S = \frac{N_1 - N_2}{N_1}$$

$$\frac{Eo}{V_1} = \frac{Zr}{Z_s}$$

$$E_2 = SEo$$

$$X_2 = SXo$$

$$I_2 = \frac{E_2}{Z_2}$$

$$Z_2 = \sqrt{R_2^2 + (SXo)^2}$$

$$Io = \frac{Eo}{Zo}$$

$$Zo = \sqrt{R_2^2 + Xo^2}$$

$$I_2 = \frac{SEo}{\sqrt{R_2^2 + (SXo)^2}}$$

$$Io = \frac{Eo}{\sqrt{R_2^2 + Xo^2}}$$

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

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

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

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Generation and supply of AC power

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

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

$$E = \sqrt{(V\ Cos\ \phi + IR)^2 + (V\ Sin\ \phi \pm IX)^2}$$

$$E = V + IR\ Cos\ \phi \pm IX\ Sin\phi$$

$$V_s = V_R \angle\theta + IR\angle 0° + IX\angle 90°$$

$$\%Reg = \frac{Vs - VR}{V} \times 100\%$$

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