PAST EXAM PAPERS & MEMOS FOR ENGINEERING STUDIES N1-N6

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higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ELECTROTECHNICS N6

(8080096)

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09:00–12:00

This question paper consists of 6 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 N6
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. Write neatly and legibly.

QUESTION 1: DC MACHINES

1.1 Name THREE types of variable losses in a DC machine. (3)

1.2 A 65 kW, 440 V DC shunt motor has an armature resistance of 0,25 ohms and a field resistance of 250 ohms respectively. The armature takes 120 A when the motor is operating at full load

Calculate the resistance that should be inserted into the armature circuit to obtain 30% speed reduction when the motor is delivering 85% of the full-load torque. (8)

1.3 List THREE ways in which the speed of a DC motor may be adjusted. (3)
[14]

QUESTION 2: AC CIRCUIT THEORY

A three-phase, star-connected alternator with a line voltage of 415 V supplies an unbalanced star-connected load with no neutral connection.

The load consists of the following impedances:

Z_R = 20 + j0 ohms
Z_Y = 10 – j0 ohms
Z_B = 15 + j0 ohms

Take V_{RN} as phasor reference and assume a phase rotation of R-Y-B.

Calculate each of the following:

2.1 Potential difference between the star point of the load and the neutral point of the alternator (7)

2.2 Potential difference across each phase of the load (3)

2.3 Current in each line (3)
[13]

QUESTION 3: TRANSFORMERS

3.1 Give TWO effects of harmonic voltages in transformers. (2)

3.2 Define the term *voltage regulation of a transformer.* (3)

3.3 A 85 kVA, 2 200/240 V, single-phase transformer has a percentage impedance of (1,5 + j4)%.

Calculate the following at a power factor of 0,75 lagging:

3.3.1 Full-load efficiency if the iron losses amount to 0,94 kW (5)

3.3.2 Maximum efficiency (3)

3.3.3 Applied primary voltage to circulate full-load current on short circuit (3)

3.3.4 The percentage regulation (2)
[18]

QUESTION 4: AC MACHINES – ALTERNATORS

4.1 Give THREE reasons for using distributed windings in a three-phase alternator. (3)

4.2 A 750 kVA, 11 kV, three-phase, short-chorded alternator has a percentage impedance of (3 + j15) percent. The power is 0,7 lagging.

Calculate the following:

4.2.1 The ohmic value of the phase resistance and reactance (6)

4.2.2 The open circuit line voltage to which the machine must be excited to deliver full-load (4)
[13]

QUESTION 5: AC MACINES – SYNCHRONOUS MOTORS

5.1 Explain with the aid of phasor diagrams, that the power factor of a synchronous motor working on a constant mechanical loads, depends on its excitation. (6)

5.2 A 5 kVA, 480 V, three-phase, 50 Hz, star-connected synchronous motor is full loaded and draws 4 kW at a leading power factor. The machine has a percentage impedance of (4 + j40) %.

Calculate the following

5.2.1 The power factor (1)

5.2.2 The resistive and reactive voltage drops (3)

5.2.3 The EMF to which the machine is excited (3)

5.2.4 The load angle in electrical degrees (1)
[14]

QUESTION 6: AC MACHINES – INDUCTION MOTORS

6.1 What is the function of an external rotor resistance starter, coupled to the slip-ring of a wound induction motor? (2)

6.2 A 480 V, six-pole, three-phase, star-connected induction motor, has a rotor impedance of (0,16 + j0,7) ohms per phase at stand still. The stand still EMF between slip-rings is 290 V.

Calculate the following:

6.2.1 The torque developed at a full-load slip of 5% (7)

6.2.2 The full-load power output if the friction and windage losses are 880 W (3)

6.2.3 The speed at maximum torque (2)
[14]

QUESTION 7: GENERATION AND DISTRIBUTION OF AC

7.1 State TWO advantages that a power factor improvement has for the consumer. (2)

7.2 The voltage supply to a consumer is 400 V, 50 Hz, three-phase. The consumer has a lighting load of 2 kW at unity power factor and a 30 kW induction motor operating at a power factor of 0,8 lagging. The efficiency of the motor is 85%.

Calculate the following:

7.2.1 The total kVA of the load (5)

7.2.2 The power factor of the load (1)

7.2.3 The value of the line current to a delta-connected capacitor bank which, when connected in parallel with the load, will limit the current taken from the mains to 60 A (6)

[14]

TOTAL: 100

FORMULA SHEET

DC MACHINES

$$E = V - Ia\ Ra$$

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

$$\frac{T_1}{T_2} = \frac{I_1\ \Phi_1}{I_2\ \Phi_2}$$

SPEED CONTROL

$$E = V - Ia\left(\frac{R\ Rse}{R + Rse} + Ra\right)$$

$$E = V - Ia\ Ra - Ise\ Rse$$

TESTING

DIRECT METHOD

$$\eta = \frac{2\pi Nr\ (W - S)}{60\ IV}$$

SWINBURNE

METHOD

$$\underset{motor}{\eta} = \frac{IV - (Ia^2 Ra + Ia_o\ V + Is\ V)}{IV}$$

$$\underset{generator}{\eta} = \frac{IV}{IV + Ia^2\ Ra + Ia_o\ V + Is\ V}$$

HOPKINSON
EFFICIENCIES
THE SAME

$$\eta = \sqrt{\frac{I_1}{I_1 + I_2}}$$

IRON LOSS

$$= I_2\,V - \left\{(I_1 + I_3)^2\ Ra + (I_1 + I_2 - I_4)^2\ Ra + (I_3 + I_4)\,V\right\}$$

$$= C$$

$$\underset{generator}{\eta} = \frac{I_1\,V}{I_1 V + (I_1 + I_3)^2\ Ra + I_3\ V + \frac{C}{2}}$$

$$\underset{motor}{\eta} = \frac{(I_1 + I_2)\,V - \left\{(I_1 + I_2 - I_4)^2\ Ra + I_4\ V + \frac{C}{2}\right\}}{(I_1 + I_2)\,V}$$

C LOADS

STAR SYSTEMS

Vrn = REFERENCE

R-Y-B SEQUENCE

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

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

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

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

BALANCED CIRCUIT $\bar{I}n = 0$

DELTA-SYSTEMS

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

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

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

THREE-WIRE

SYSTEMS

$$V_{sn} = \frac{\frac{\bar{V}_{an}}{\bar{Z}_1} + \frac{\bar{V}_{bn}}{\bar{Z}_2} + \frac{\bar{V}_{cn}}{\bar{Z}_3}}{\frac{1}{\bar{Z}_1} + \frac{1}{\bar{Z}_2} + \frac{1}{\bar{Z}_3}}$$

$$\bar{V}_{aN} = \bar{V}_{aS} + \bar{V}_{sN}$$

$$\bar{V}_{bN} = \bar{V}_{bS} + \bar{V}_{sN}$$

$$\bar{V}_{cN} = \bar{V}_{cS} + \bar{V}_{sN}$$

$$\bar{I}_a = \frac{\bar{V}_{aS}}{\bar{Z}_1}$$

$$\bar{I}_B = \frac{\bar{V}_{bS}}{\bar{Z}_2}$$

$$\bar{I}_C = \frac{\bar{V}_{cS}}{\bar{Z}_3}$$

COMPLEX WAVE FORMS

$$e_1 = E_m \ Sin \ \omega t$$

$$e_2 = K_2 \ E_m \ Sin \ 2 \ \omega t$$

$$e_3 = K_3 \ E_m \ Sin \ 3 \ \omega t$$

$$e = E_m \ (Sin \ \omega t + k_2 \ Sin \ 2 \ \omega t + k_3 \ Sin \ 3 \ \omega t)$$

$$P = \frac{E_m^2 1 + E_m^2 2 + E_m^2 3 + ... + E_m^2 N}{2R}$$

$$P = \left(I_m^2 1 + I_m^2 2 + I_m^2 3 + ... + I_m^2 N\right) R$$

$$I = \sqrt{\frac{I_m^2 1 + I_m^2 2 + ... + I_m^2 N}{2}}$$

$$E = \sqrt{\frac{E_m^2 1 + E_m^2 2 + ... + E_m^2 N}{2}}$$

$$Cos \ \phi = \frac{I^2 \ R}{E \ I} = \frac{\frac{E^2}{R}}{E \ I}$$

TRANSFORMERS

$$\eta = \frac{S \ Cos \ \phi}{S \ Cos \ \phi + Po + Psc}$$

Any value of load

at k of full-load

$$\eta = \frac{k \ S \ Cos \ \phi}{k \ S \ Cos \ \phi + Po + k^2 \ Psc}$$

MAXIMUM EFFICIENCY

$$K = \sqrt{\frac{Po}{Psc}}$$

$$\eta = \frac{k \ S \ Cos \ \phi}{k \ S \ Cos \ \phi + Po + k^2 \ Psc}$$

FORMULAE

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

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

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

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

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

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

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

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

$$Reg = \frac{I \, (Re \, Cos \, \phi_2 \pm Xe \, Sin \, \phi_2)}{V}$$

AC MACHINES

ALTERNATORS

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

$$Kd = \frac{Sin \frac{n\alpha}{2}}{n \, Sin \frac{\alpha}{2}}$$

$$Kp = Cos \, \frac{\psi}{2}$$

$$E = 2 \, Kf \, Kd \, Kp \, f \, \Phi \, Z$$

$$E = \sqrt{(V \, Cos \, \phi + IR)^2 + (V \, Sin \, \phi \pm I\!X}$$

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

$$\overline{E} = E \, \underline{|\phi} + IR \, \underline{|o} + Ix \, \underline{|90}$$

$$Reg = \frac{E - V}{V}$$

SYNCHRONOUS MOTOR

$$\overline{V} + \overline{E} = \overline{E}_R \qquad \overline{E}_R = \overline{IZ}$$

$$\overline{E} = V \, \underline{|-\phi} + IR \, \underline{|180^\circ} + IX \, \underline{|-90^\circ}$$

INDUCTION MOTOR

$$\frac{Eo}{V_1} = \frac{Zr}{Z_s} \qquad E_2 = SEo$$

$$X_2 = SXo \qquad I_2 = \frac{E_2}{Z_2}$$

$$Z_2 = \sqrt{R_2^2 + (SXo)^2} \qquad Io = \frac{Eo}{Zo}$$

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

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

MAXIMUM EFFICIENCY

$$R_2 = SXo$$

Rotor copper loss = S rotor input

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

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

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