higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ELECTROTECHNICS N6

(8080096)

10 August 2021 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

This question paper consists of 5 pages and a formula sheet of 5 pages.

251Q1G2110

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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. Keep subsections of questions together.
6. Round all calculations off to THREE decimal places.
7. Use the correct symbols and units.
8. Use a pen to write and do all DRAWINGS/SKETCHES/DIAGRAMS in PENCIL only.
9. Write neatly and legibly.

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QUESTION 1: DC MACHINES

1.1 Explain how the speed of a DC motor varies in relation to the following:

1.1.1 The armature voltage

1.1.2 The field current

(2 × 2) (4)

1.2 A 400 V DC series motor with an armature resistance of 0,4 Ω takes a current of 25 A when running at 750 r/min. Assume the flux to be proportional to the current.

Calculate the following:

1.2.1 The speed when the motor takes a current of 40 A (6)

1.2.2 The ratio of the two torques developed (3)

[13]

QUESTION 2: AC CIRCUIT THEORY

2.1 Explain the concept *complex wave.* (2)

2.2 An EMF represented by e = 140,44 Sin 314t + 80,72 Sin 1 570t is applied across a resistor of 10 Ω in parallel with an inductor of 0,02 H.

Calculate the following:

2.2.1 The power absorbed by the circuit (3)

2.2.2 The RMS value of the current supplied to the circuit (10)

[15]

QUESTION 3: TRANSFORMERS

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

3.2 Name TWO effects of harmonic voltages in a transformer. (2)

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3.3 The percentage impedance referring to the primary coil of a 250 kVA, 1 800/450 V single-phase, 50 Hz transformer is (0,6 + j4,4) Ω. The power factor is 0,8 lagging.

Calculate the following:

3.3.1 The turns ratio (2)

3.3.2 The percentage resistance (3)

3.3.3 The percentage reactance (2)

3.3.4 The full-load copper loss (2)

3.3.5 The power factor at which maximum regulation occurs (2)

3.3.6 The voltage to be applied to the primary to circulate full-load current in the secondary circuit (2)

[18]

QUESTION 4: AC MACHINES – ALTERNATORS

A three-phase, star-connected alternator on open-circuit is required to generate a line voltage of 3 600 V, 50 Hz, when driven at 500 r/min. The stator has THREE slots per pole per phase and 20 conductors per slot.

Assume ALL the conductors per phase to be connected in series and the coils to be full pitched. The distribution factor is 0, 96.

4.1 Calculate the number of poles (3)

4.2 Calculate the useful flux per pole (8)

[11]

QUESTION 5: AC MACHINES – SYNCHRONOUS MOTORS

5.1 What is a *synchronous capacitor*? (2)

5.2 A three-phase synchronous motor is connected in parallel with a load of 500 kW at a power factor of 0,75 lagging. The excitation of the motor is adjusted until the total power factor is 0,9 lagging. The input of the motor is 100 kW.

5.2.1 Calculate the kVA input to the motor. (7)

5.2.2 Calculate the power factor of the motor. (1)

[10]

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QUESTION 6: AC MACHINES – INDUCTION MOTORS

6.1 Define *torque in synchronous watts*. (2)

6.2 Name the TWO main parts of an induction motor. (2)

6.3 The power input to the rotor of a 440 V, 50-Hz, 6-pole induction motor is 100 kW. The rotor electromotive force is observed to make 120 cycles per minute.

Calculate the following:

6.3.1 The slip

6.3.2 The rotor speed

6.3.3 The mechanical power developed

6.3.4 The rotor copper loss per phase

6.3.5 The speed of the stator field with respect to the rotor

(5 × 2) (10)
[14]

QUESTION 7: GENERATION AND SUPPLY OF AC

7.1 Define *regulation of a transmission line*. (3)

7.2 State THREE effects of a poor power factor. (3)

7.3 Apply the π-method to calculate the sending end voltage, current and power factor of a 150 km transmission line.

The line delivers a three-phase load of 15 MW at a power factor of 0,8 lagging and a line voltage of 90 kV, 50 Hz.

Each conductor has a resistance of 0,285 Ω/km, an inductance of 1,845 milli-henry/km (mH/km) and a capacitance of 0, 00863 µF/km to neutral.

NOTE: Draw the π-method circuit diagram (13)
[19]

TOTAL: 100

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FORMULA SHEET

GS-MASJIENE ***DC MACHINES***

$$E = V - Ia\,Ra$$

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

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

SPOEDBEHEER ***SPEED CONTROL***

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

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

TOETSING ***TESTING***

DIREKTE METODE ***DIRECT METHOD***

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

SWINBURNE- ***SWINBURNE***

METODE ***METHOD***

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

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

HOPKINSON- ***HOPKINSON***

RENDEMENTE ***EFFICIENCIES***

DIESELFDE ***THE SAME***

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

YSTER- ***IRON LOSS***

VERLIES

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

$$= C$$

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

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

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WS-BELASTING
STERSTELSELS

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

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

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

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

AC LOADS
STAR SYSTEMS

$\bar{}$
Vrn = VERWYSING
REFERENCE

R-Y-B VOLGORDE
SEQUENCE

GEBALANSEERDE KRING $\bar{I}n = 0$ ***BALANCED CIRCUIT***

DELTASTELSELS ***DELTA-SYSTEMS***

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

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

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

DRIEDRAAD-
STELSELS

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

THREE-WIRE
SYSTEMS

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

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

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

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

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

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

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KOMPLEKSE GOLFVORMS ***COMPLEX WAVE FORMS***

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

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

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

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

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

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

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

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

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

TRANSFORMATORS ***TRANSFORMERS***

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

Enige waarde van belasting by k van vollas

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

Any value of load at k of full-load

MAKSIMUM RENDEMENT ***MAXIMUM EFFICIENCY***

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

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

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FORMULES ***FORMULAE***

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

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

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

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

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

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

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

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

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

WS-MASJIENE ALTERNATORS ***AC MACHINES ALTERNATORS***

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

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

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

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

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

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

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

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

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SINCHRONE MOTOR $\overline{V} + \overline{E} = \overline{E}_R \quad \overline{E}_R = \overline{IZ}$ ***SYNCHRONOUS MOTOR***

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

INDUKSIEMOTOR ***INDUCTION MOTOR***

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

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

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

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

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

MAKSIMUM RENDEMENT ***MAXIMUM EFFICIENCY***

$$R_2 = SXo$$

Rotorkoperverlies = S rotorinset
Rotor copper loss = S rotor input

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

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

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

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