higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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AUGUST 2010

NATIONAL CERTIFICATE

ELECTROTECHNICS N6

(8080096)

22 July (X-Paper)
09:00 – 12:00

REQUIREMENTS: Graph paper

Calculators may be used.

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

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 correctly 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. Write neatly and legibly.

QUESTION 1

1.1 Explain how the speed of a DC shunt motor may be changed to the following:

1.1.1 Above normal speed (2)

1.1.2 Below normal speed (2)

1.2 The following results were obtained from a Hopkinson test on two identical DC shunt machines:

Armature resistance of each machine	= 0,03 ohms
Terminal voltage of each machine	= 250 V
Input current from the supply	= 50 A
Motor field current	= 4,8 A
Generator field current	= 4 A
Motor armature current	= 370 A

Calculate the efficiency of the machine operating as a generator, assuming:

1.2.1 Equal iron and friction losses (10)

1.2.2 Equal efficiencies (2)

[16]

QUESTION 2

A voltage represented by: $e = 150 \sin 314t + 50 \sin (942t + 60°)$ volts is applied to a circuit consisting of a resistor of 15 ohms in parallel with an inductor of 32 millihenry and negligible resistance.

Calculate the following:

2.1 An expression for the instantaneous value of the current (10)

2.2 The RMS value of the current and voltage (4)

2.3 The power absorbed by the circuit (2)

2.4 The energy dissipated in the circuit during 3 milli-seconds (1)

[17]

QUESTION 3

3.1 What are the effects of harmonic voltages in transformers? (3)

3.2 A 165 kVA single-phase transformer has a voltage ratio of 3 300/660 V. The primary short circuit voltage is 358,5 V and the short circuit power is 3,875 kW. The iron loss is 900 W and the power factor is 0,8 lagging.

Calculate the following:

3.2.1 The equivalent resistance and reactance referred to the primary (7)

3.2.2 The percentage full load voltage regulation (2)

3.2.3 The efficiency at half load (2)

3.2.4 The maximum efficiency (3)

[17]

QUESTION 4

4.1 What is meant by the *coil span factor* of an alternator? (2)

4.2 A 12 kV, three-phase, 2 MVA, star-connected alternator operates at a power factor of 0,8 lagging and has a synchronous impedance of (1,2 + j8) ohms.

Calculate the following:

4.2.1 The open-circuit line voltage to which the machine must be excited to deliver full-load (7)

4.2.2 The regulation of the alternator (2)

4.2.3 The load angle at which the machine operates (1)

[12]

QUESTION 5

5.1 Draw the circle diagram of a 30 kW, 400 V, 50 Hz, 4-pole, star-connected, three-phase induction motor, given the following additional data:

No-load test:	20 A	400 V	3 464 W
Locked rotor test:	80 A	200 V	9 700 W

The stator resistance per phase is 0,2 ohms.

Use scale 1 cm = 8 A (10)

5.2 Determine the following from the circle diagram:

5.2.1 The line current at maximum torque (1)

5.2.2 The power factor at maximum torque (1)

5.2.3 The efficiency at maximum torque (1)

5.2.4 The slip at maximum torque (1)

5.2.5 The rotor copper losses at standstill. (1)

[15]

QUESTION 6

A synchronous motor is connected in parallel to a load of 1 000 kW at a power factor of 0,7 lagging. If the combined load has a power factor of 0,85 lagging and the synchronous motor takes 150 kW from the supply, calculate the following for the synchronous motor:

6.1 The kVA (5)

6.2 The kVAr (1)

6.3 The power factor (1)

[7]

QUESTION 7

Apply the π method to calculate the sending end voltage, current and power factor of a 200 km transmission line. The line delivers a three-phase load of 20 MW at a power factor of 0,8 lagging and a line voltage of 132 kV, 50 Hz.

Each conductor has a resistance of 0,3 ohms/km, an inductance of 1,95 millihenry/km and a capacitance of 0,0093 micro-farad/km to neutral.

IMPORTANT: Draw the π method circuit diagram. **[16]**

TOTAL: 100

ELECTROTECHNICS N6

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 DIREKTE METODE — ***TESTING DIRECT METHOD***

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

SWINBURNE-METODE — ***SWINBURNE 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-RENDEMENTE DIESELFDE — ***HOPKINSON EFFICIENCIES THE SAME***

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

YSTER-VERLIES — ***IRON LOSS***

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

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

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

WS-BELASTING *STERSTELSELS* / ***AC LOADS*** *STAR SYSTEMS*

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

$\bar{V}rn$ = VERWYSING / REFERENCE

$$\bar{I}_Y = \frac{V \angle -120^\circ}{Z_{YN} \angle \phi_2}$$

R-Y-B VOLGORDE / SEQUENCE

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

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

GEBALANSEERDE KRING / ***BALANCED CIRCUIT***

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

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 / ***THREE-WIRE SYSTEMS***

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

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

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

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

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

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

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

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 *Any value of load at k of full-load*

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

MAKSIMUM RENDEMENT ***MAXIMUM EFFICIENCY***

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

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

INDUKSIEMOTOR / *INDUCTION MOTOR*

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

$$E_2 = SEo$$

$$X_2 = SXo$$

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

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

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

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

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

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

MAKSIMUM RENDEMENT / *MAXIMUM EFFICIENCY*

$$R_2 = SXo$$

Rotorkoperverlies = S rotorinset
Rotor copper loss = S rotor input

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

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

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