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education

Department:
Education
REPUBLIC OF SOUTH AFRICA

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APRIL 2010

NATIONAL CERTIFICATE

ELECTROTECHNICS N6

(8080096)

24 March (X-Paper)
09:00 – 12:00

Calculators may be used.

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

DEPARTMENT OF EDUCATION
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 you would use the Swinburne's method to find the efficiencies of a DC shunt motor at any load. (8)

1.2 A 400 V, DC-series motor takes 100 A from the supply when running at 600 r/min. The armature and series field resistances are 0,2 and 0,1 ohms, respectively.

Calculate the speed of the motor when a resistance of 0,075 ohms, in parallel with the torque, remains constant. Assume the flux to be proportional to the field current. (9)
[17]

QUESTION 2

A 380 V, unbalanced, three-phase, delta-connected load takes the following phase currents:

I_{RY} = 20 + j0 Amperes

I_{YB} = 25 – j10 Amperes

I_{BR} = 30 +j15 Amperes

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

Calculate the following:

2.1 The impedance of each load (6)

2.2 The current in each line (6)
[12]

QUESTION 3

3.1 Name TWO types of constant losses in a transformer. (2)

3.2 The impedance that refers to the primary of a 250 kVA, 1 500/500 V, single-phase transformer is (0,5 + j4) ohms. The power factor is 0,8 lagging.

Calculate the following:

3.2.1 The turns ratio (2)

3.2.2 The percentage resistance (3)

3.2.3 The percentage reactance (2)

3.2.4 The full-load copper loss (2)

3.2.5 The voltage to be applied to the primary to circulate full-load current in the secondary circuit (2)
[13]

QUESTION 4

4.1 Explain, with the aid of a neat diagram, how a short-circuit test is carried out on a three-phase, star-connected alternator. (5)

4.2 A three-phase, eight-pole, star-connected alternator has a single layer winding with 16 conductors per slot. The armature has a total of 48 slot. Each turn of the winding spans 120° electrical. The alternator is driven at 750 r/min with a flux of 50 mWb in each pole.

Calculate the open-circuit line voltage. (12)
[17]

QUESTION 5

5.1 Explain, with the aid of phasor diagrams, what happens when the load torque of a synchronous motor is increased. (4)

5.2 A 175 kVA, 3,3 kV, 6-pole, three-phase, star-connected synchronous motor has a percentage synchronous impedance of (4 + j45) per cent. The machine is fully loaded at a power factor of 0,8 leading.

Calculate the following:

5.2.1 The ohm value of the phase resistance and reactance (4)

5.2.2 The EMF to which the machine is excited (5)

5.2.3 The load angle in electrical and mechanical degrees (2)
[15]

QUESTION 6

The standstill EMF of a three-phase, 50 Hz, 4-pole induction motor with a star-connected rotor is 300 V between slip-rings. The standstill rotor impedance is (0,3 + j1,7) ohms per phase.

If the torque of the motor is gradually increased, calculate the following:

6.1 The slip at maximum torque (2)

6.2 The rotor current per phase at maximum torque (2)

6.3 The rotor starting current (2)

6.4 The rotor copper losses at starting (2)

6.5 The rotor speed at maximum torque (2)
[10]

QUESTION 7

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

7.2 Use the T-method and calculate the following of a three-phase transmission line:

7.2.1 The sending current (8)

7.2.2 The sending voltage (4)

7.2.3 The power factor (1)

The line delivers a load of 40 MW at a power factor of 0,8 lagging and a line voltage of 132 kV. Each conductor has a resistance of 15 ohms, an inductive reactance of 45 ohms and a capacity reactance to neutral of 2 500 ohms. **[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***

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

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

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

PTO

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

$$\overline{I}_R = \frac{V\underline{|0^\circ}}{Z_{RN}\underline{|\phi_1}}$$

$$\overline{I}_y = \frac{V\underline{|-120^\circ}}{Z_{YN}\underline{|\phi_2}}$$

$$\overline{I}_B = \frac{V\underline{|120^\circ}}{Z_{BN}\underline{|\phi_3}}$$

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

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

R-Y-B VOLGORDE / SEQUENCE

GEBALANSEERDE KRING / ***BALANCED CIRCUIT***

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

DELTASTELSELS / ***DELTA-SYSTEMS***

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

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

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

DRIEDRAAD-STELSELS / ***THREE-WIRE SYSTEMS***

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

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

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

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

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

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

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

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***

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

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

PTO

FORMULES **FORMULAE**

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

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

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

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

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

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

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

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

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

WS-MASJIENE ALTERNATORS **AC MACHINES ALTERNATORS**

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

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

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

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

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

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

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

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

SINCHRONE MOTOR **SYNCHRONOUS MOTOR**

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

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

PTO

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

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

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

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