higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

APRIL EXAMINATION

ELECTROTECHNICS N5

6 APRIL 2016

This marking guideline consists of 12 pages.

QUESTION 1

1.1 By reversing either the field✓ or armature connections.✓ (2)

1.2 They are placed in slots in the pole shoes.✓ They are connected in series with the armature windings.✓ (2)

1.3 1.3.1 Ampere turns required on no load = 6 x 2 100 = 12 600✓

Ampere turns required on full load = 7,5 x 2 100 = 15 750✓

Ampere turns required on series field on full load = 15 750 – 12600

= 3 150✓

Full-load line current IL = P/V

$= \frac{355 \times 10^3}{580}$

= 612,07 A ✓

Constant field current If = 6A

Ia = IL + If

= 618,07 A

Turns required on series field $= \frac{3\ 150}{618,07}$

= 5,1 ✓

say 6 (5)

1.3.2 With series winding of 12 t/p and resistance of 0,08 Ω

Ampere turns required = 3 150

Series field current If = 3 150/12 ✓

= 262,5A ✓

Current through diverter Rx = 618,07 – 262,5

= 355,57 A ✓

Voltage across diverter = voltage across series field

(Ix) (Rx) = If (series) × R (series)

Rx $= \frac{262,5 \times 0,08}{355,57}$✓

= 0,06 Ω✓ (5)

1.4 P = 35 kW V = 625 p = 2 (4 pole) c = 2 wave-wound
Z = 900 segments = 150 brush shift = 1,5 segments
Ish = 2,25 A Eff = 85%

θ Mechanical ° $= \frac{1,5}{180} \times 360° = 3°$

θ Electrical ° = p × mechanical °

$= 2 \times 3° = 6°$ ✓

Efficiency = 85 % = 0,85

Input $= \frac{\text{Output}}{\text{Efficiency}} = \frac{35}{0,85} = 41,176$ kW ✓

$I_L = \frac{P\ in}{V} = \frac{41176}{625} = 65,88$ A ✓

$I_a = I_L - Ish = 65,88 - 2.25 = 63,63$ A

At / p $= \frac{I\,Z}{2c2p}$

$= \frac{(63,63)(900)}{2 \times 2 \times 2 \times 2}$

$= 3\,579,18$ ✓

Demag At / p $= \frac{IZ}{2c\,2p} \times \frac{4\,\theta}{360}$

$= 3\,579,18 \times \frac{4\,(6)}{360}$

$= 238,61$ ✓

Cross At / p $= \frac{I\,Z}{2c\,2p} \times [1 - \frac{4\,\theta}{360}]$

$= 3\,579,18\,[1 - 0,066]$

$= 3\,342,95$ ✓ (6)

[20]

QUESTION 2

2.1 2.1.1 $V = 800 \sin(314t + 30)$

$I = 8 \sin(314t + 30)$

$ZT = \dfrac{800 < 30}{8 < 30} = 100 < 0$ ✓

NATURE

It is a pure resistance because the current is in phase with the voltage.✓

MAGNITUDE : 100 ohms✓ (3)

2.1.2 Time period (t) of the wave

$\sin 314t + 30$

$= \sin 2\pi f t + 30$ ✓

$2\pi f = 314$

$f = 314 / 2\pi = 49{,}97 \text{ Hz}$ ✓

$t = 1/49{,}97 = 20 \text{ ms}$ ✓ (3)

2.2 2.2.1 $fr = \dfrac{1}{2\pi\sqrt{LC}}$

$10^6 = \dfrac{1}{2\pi\sqrt{140 \times 10^{-6}(C)}}$

$\sqrt{140 \times 10^{-6}(C)} = \dfrac{1}{2\pi 10^6}$ ✓

$140 \times 10^{-6}(C) = \left(\dfrac{1}{2\pi 10^6}\right)^2$

$= 2{,}533 \times 10^{-14}$ ✓

$C = 1{,}809 \times 10^{-10}$

$= 180{,}9 \times 10^{-12}$ 180,9 pf✓ (3)

2.2.2 $ZP = \frac{L}{CR} = \frac{140 \times 10^{-6}}{180,9 \times 10^{-12} \times 8,25}$ ✓

$= 93\ 807,06\ \Omega$ ✓ (2)

2.2.3 $RT = ZP + R\ ser$

$= 93\ 807,06 + 7\ 300$

$= 101\ 107,06\ \Omega$ ✓

$IT = \frac{V}{RT} = \frac{380}{101107,06} = 3,76\ mA$ ✓

$VP = IT \times ZP = 0,00376 \times 93\ 807,06$

$= 352,71\ V$ ✓

$XL = 2\pi f L = XC$

$= 2\pi (10^{6})(140 \times 10^{-6})$ ✓

$= 879,65$ ✓

$Z\ coil = \sqrt{R^2 + XL^2}$

$= \sqrt{8,25^2 + (879,65)^2}$

$= 879,69$ ✓

$I\ coil = \frac{VP}{Zcoil}$

$= \frac{352,71}{879,69}$

$= 400,95\ mA$ ✓

$IL = 400,95\ mA$ ✓ $= IC$

OR

$IC = \frac{VP}{XC}$

$= \frac{352,71}{879,65}$

$= \underline{400,96}mA$ ✓ (9)

[20]

QUESTION 3

3.1 Making the transformer window long and narrow.✓
Arranging primary and secondary windings concentrically.✓
Sandwiching primary and secondary windings. ✓
Using shell-type construction.✓ (Any 3 × 1) (3)

3.2 Single-phase transformer

24 kVA 3200 /800

$$\frac{N1}{N2} = \frac{V1}{V2} = \frac{3200}{800} = 4$$

$R_1 = 8,4 \quad x_1 = 14,4$

$R_2 = 0,75 \quad x_2 = 1,5$

$\text{Cos}\ \Phi = 0,8 \quad \Phi = 36,87$

$Re = R_1 + R_2\ (N_1/N_2)^2$

$= 8,4 + 0,75\ (4)^2$

$= 20,4$✓

$Xe = X_1 + X_2\ (N_1/N_2)^2$

$= 14,4 + 1,5\ (4)^2$

$= 38,4$ ✓

$Ze = Re + j\ Xe$

$= 20,4 + j\ 38,4$

$= 43,48 < 62$ ✓

$VA = I_1 \times 3200 \quad I_1 = \frac{24000}{3200} = 7,5\ A$

$$Reg = \frac{I_1 (Re \cos\Phi + Xe \sin\Phi)}{V1}$$

$$= \frac{7,5 [20,4 (0,8) + 38,4 (0,6)]}{3200} \checkmark$$

= 0,092 p.u.

= 9,2 % ✓

Vd = 800 × 0,092

= 73,6 V ✓

Full load V2 = No load V2 - volt drop

= 800 – 73,6

= 726,4 V ✓ (7)

3.3 3.3.1 $X_L = 2\pi f L$

$= 2\pi \times 50 \times 0,038$

= 11,94 ✓

Z1 = Z2 = Z3 = 29 + j 11,94

= 31,36 < 22,378✓

VL = Vp = 535 V

$$I p = \frac{Vp}{Z1} = \frac{535 < 0}{31,36 < 22,378} \checkmark$$

= 17,06 < - 22,378✓

IL = $\sqrt{3}$ I p

= $\sqrt{3}$ × 17,06✓

= 29,55 A✓ (6)

3.3.2 Pf = Cos Φ = Cos 22,378✓ = 0,925 lagging✓ (2)

3.3.3 P = $\sqrt{3}$ VL IL Cos Φ

= $\sqrt{3}$ × 535 × 29,55 × 0,925✓

= 25 329 kW✓

(2)

[20]

QUESTION 4

4.1 4.1.1 $P_T = \sqrt{3}\ V_L\ I_L\ \cos\phi$

$$I_L = \frac{135000}{\sqrt{3} \times 2950 \times 0{,}85}$$

$= 31{,}08$ A✓

$I_P = \frac{I_L}{\sqrt{3}} = 31{,}08 / \sqrt{3} = 17{,}94$ A✓ (2)

4.1.2 $W1 = V_L\ I_L\ \cos(30 + \phi)$ $\phi = 31{,}79$
$= 2\,950 \times 31{,}08 \cos(30 + 31{,}79)$✓
$= 2\,950 \times 31{,}08 \cos(61{,}79)$
$= 43{,}34$ kW✓

$W2 = V_L\ I_L\ \cos(30 - \phi)$

$= 2\,950 \times 31{,}08 \cos(30 - 31{,}79)$✓
$= 91{,}64$ kW✓ (4)

4.1.3 $$kVA = \frac{\sqrt{3}\ V_L\ I_L}{1000}$$

$$= \frac{\sqrt{3} \times 2950 \times 31{,}08\ A}{1000}$$ ✓

$= 158{,}8$ kW✓ (2)

4.2 4.2.1 Load $P = 1{,}73\ MW = \frac{1{,}73MW}{3}$ per phase

$\cos \phi = 0{,}75$ lagging ($\sin \phi = 0{,}66$)

$Vr = \frac{35000}{\sqrt{3}} (\cos \phi + j \sin \phi)$

$= \frac{35000}{\sqrt{3}} (0{,}75 + j\,0{,}66)$

$= 15\,155{,}44 + j\,13\,336{,}79$ ✓

$I\,p = \frac{1{,}73 \times 10^6}{\sqrt{3}.35000.0{,}75} = 38{,}05\ A$ ✓

$Vd = I\,Z = 38{,}05\ (85 + j\,155)$

$= 3\,234{,}25 + j\,5\,897{,}75$ ✓

$Vs = Vr + Vd$
$= 15\,155{,}44 + j\,13\,336{,}79 + 3\,234{,}25 + j\,5\,897{,}75$
$= 18\,389{,}69 + j\,19\,234{,}54$
$= 26\,611{,}055 < 46{,}286$ ✓

Vs line voltage $= \sqrt{3} \times 26\,611{,}055 = 46\,091{,}69$ kV ✓ (5)

4.2.2 $Reg = \frac{Vs - Vr}{Vr}$

$= \frac{26611{,}055 - 20207{,}26}{20207{,}26}$ ✓ $35000/\sqrt{3} = 20207{,}26$

$= 0{,}317$ p.u. ✓

OR ALTERNATE

$Reg = \frac{Vs - Vr}{Vr}$

$= \frac{46091{,}69 - 35000}{35000}$

$= 0{,}317$ p.u. (2)

4.2.3 Output = 1,73 MW/3 per phase = 576,67kW✓

Power loss = I^2R

= $(38,05)^2 \times 85$

= 123,06 kW✓

Input = output + losses

= 576,67+ 123,06

= 699,73 kW✓

Efficiency = $\frac{\text{output}}{\text{Input}}$

= $\frac{576,67}{699,73}$ ✓

= 0,824 (82,4 %)✓ (5)

[20]

QUESTION 5

5.1 Sudden changes of load on synchronous motors sometimes set up oscillations that are superimposed upon the normal rotation✓ giving rise to periodic variations in speed of a very low frequency.✓ (2)

5.2 5.2.1 Slip-ring motor VL = 95

$E_o = \frac{95}{\sqrt{3}}$ = 54,85 V (star rotor)✓

Z_o = 0,7 + j 9

Z_{st} = 4 + j 7

Starting Z_o = (0,7 + j 9) + (4 + j 7)✓

= 4,7 + j16

= 16,68 < 73,63 ✓

$I_o = \frac{E_o}{Z_0} = \frac{54,85}{16,68}$ = 3,29A✓ (4)

5.2.2 $E2 = s\,Eo = (0{,}05)(54{,}85) = 2{,}74$

$X2 = s\,Xo = (0{,}05)(9) = 0{,}45$

$Z2 = \sqrt{(R2)^2 + (X2)^2}$

$= \sqrt{(0{,}7)^2 + (0{,}45)^2} = 0{,}83$ ✓

$I_2 = \frac{E2}{Z2} = \frac{2{,}74}{0{,}83} = 3{,}3\text{ A}$ ✓ (2)

5.3 5.3.1 $Eo = 145/\sqrt{3} = 83{,}72\text{ V}$ ✓

$I_2 = \frac{Eo}{Zo}$

$= \frac{83{,}72}{\sqrt{(R2)^2 + (Xo)^2}}$ ✓

$= \frac{83{,}72.}{\sqrt{(1{,}25)^2 + (6{,}75)^2}}$ ✓

$= \frac{83{,}72}{6{,}86}$

$= 12{,}2\text{ A}$ ✓ (4)

5.3.2 $\tan \Phi = \frac{Xo}{R2} = \frac{6{,}75}{1{,}25} = 5{,}4$ ✓

$\Phi = 79{,}51$

$\cos \Phi = 0{,}182$ ✓ (2)

5.4 5.4.1 $f = \frac{np}{60}$

$P = \frac{60 \times 60}{1200} = 3$ ✓

poles = 6 ✓ (2)

5.4.2 8 = slots / pole / phase

= slots / 6 / 3 ✓

slots = 8 × 6 × 3 = 144

Z = 144 × 6 = 864 ✓

Ep = 2,22 kd kp Φ f Z / phase

$\frac{885}{\sqrt{3}}$ √ = 2,22 (0,96) (1) Φ (60) ($\frac{864}{3}$) ✓

Φ = 0,0139 Wb. ✓ (4)

[20]

TOTAL: 100