higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

NOVEMBER EXAMINATION

ELECTROTECHNICS N5

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This marking guideline consists of 9 pages.

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QUESTION 1

1.1 No.✓
At no-load the field flux is too small to allow the build-up of the necessary back EMF which causes the motor to speed up towards infinity until it burns out completely.✓ (2)

1.2 Back EMF is the voltage which is generated due to the armature conductors moving through the magnetic field flux.✓
This voltage is in opposition to the applied voltage by which it is generated.✓
The motor will speed up until the necessary back EMF is built up because a low back EMF will cause a high armature current which will supply the extra driving torque to speed up the armature.✓ Any change in the back EMF will result in a change of speed. The back EMF acts like a governor and therefore the motor is self-regulating.✓ (4)

1.3 Pole = 6 p = 3

$c = 2p = 2 \times 3 = 6$ ✓ $Z = 600$

$$\frac{\text{Pole arc}}{\text{Pole pitch}} = 0{,}8$$

$I = 790 \text{ A}$

$$\text{At / p} = \frac{IZ}{2c\,2p} \times \frac{\text{Pole arc}}{\text{Pole pitch}}$$

$$= \frac{790 \times 600}{2 \times 6 \times 2 \times 3} \times 0{,}8 \quad ✓✓$$

$$= 5266{,}67 \text{ At} \quad ✓$$

Say 5267 At (4)

1.4 $I = \frac{88000}{435} = 202{,}3\text{A}$ ✓

At / p for full load = 10,5 A × 1800 t/p ✓ = 18900 At / p ✓

t / p for no load = 6,5 A × 1800 t/p ✓ = 11700 At / p ✓

At / p for series winding = 18900 – 11700 ✓

= 7200 At / p ✓

No of series t/p = 7200 / 202,3
= 35,6 ✓
Say 36 (8)

1.5 Lap windings are used in low-voltage and high-current machines. (1)

Wave windings are used in high-voltage and low-current machines. (1)
[20]

QUESTION 2

2.1 $C1 = 380 \times 10^{-12}$ F (I max)

$C2 = 350 \times 10^{-12}$ F ($I_2 = 0,707$ I max)

$XC1 = 1/2\pi fc = \dfrac{1 \times 10^{12}}{2\pi \times 0,84 \times 10^{6} \times 380} = 498,6\ \Omega$ ✓

$XL1 = XC1 = 498,6$ (resonance) ✓

$XL1 = 2\pi f L$

$L = \dfrac{XL}{2\pi f} = \dfrac{498,6}{2\pi \times 0,84 \times 10^{6}} = 94,47\ \mu H$ ✓

$XC_2 = 1/2\pi fC_2 = \dfrac{10^{12}}{2\pi \times 0,84 \times 10^{6} \times 350}$ ✓ $= 541,34\ \Omega$ ✓

Increase in XC $= 541,34 - 498,6 = 42,74\ \Omega$ ✓

$Z^2{}_2 = R^2 + (42,74)^2$ ✓

$Z_2 = \sqrt{R^2 + (42,74)^2}$

$I_1 = V/Z1$

$I_2 = 0,707\ I_1 = 0,707\ V/Z_1 = V/Z_2$

$Z1 = R$ (resonance)

$0,707\ V/Z_1 = V/Z_2$

$0,707\ V/R = V / \sqrt{R^2 + (42,74)^2}$

$(0,707\ V/R)^2 = \left[V / \sqrt{R^2 + (42,74)^2} \right]^2$ ✓

$\dfrac{(0,707\ V)^2}{R^2} = V^2 / R^2 + (42,74)^2$

$$\frac{R^2 + (42{,}74)^2}{R^2} = \frac{V^2}{(0{,}707\ V)^2}$$

$$1 + \frac{(42{,}74)^2}{R^2} = \frac{1}{(0{,}707)^2} \checkmark$$

$$\frac{(42{,}74)^2}{R^2} = \frac{1}{(0{,}707)^2} - 1 = 1{,}001$$

$$R^2 = \frac{(42{,}74)^2}{1{,}001}$$

$$R = 42{,}7 \text{ ohms} \checkmark$$ (10)

2.2 2.2.1 $X_L = 2\pi f L$

$= 2\pi \times 3 \times 10^6 \times 375 \times 10^{-6} \checkmark = 7068{,}58\ \Omega\surd$

$f(res) = 1 / 2\pi\sqrt{LC}$

$3 \times 10^6 = 1 / 2\pi\sqrt{375 \times 10^{-6} \times C} \checkmark$

$\sqrt{375 \times 10^{-6} \times C} = 1 / 2\pi\, 10^6 \times 3 \checkmark$

$375 \times 10^{-6} \times C = (1 / 2\pi 10^6 \times 3)^2 \checkmark$

$C = 7{,}49 \times 10^{-12}\ F \checkmark$ (5)

2.2 2.2.2 Z parallel = L/CR

$= \frac{375 \times 10^{-6}}{7{,}49 \times 10^{-12} \times 33} \checkmark$

$= 1517{,}174\ k\Omega \checkmark$ (2)

2.2.3 $I = V/Z_T$

$= 120 / 6400 + 1517174$

$= 120 / 1523574$

$= 0{,}079$ mA

pd across coil $= 0{,}079 \times 10^{-3} \times 1517174 = 119{,}857$ V $\checkmark$

I coil $= 119{,}857 / \sqrt{(33)^2 + (7068{,}58)^2}$

$= 16{,}4$ mA $\checkmark$

I cap $= 2 \times 3{,}14 \times 2{,}2 \times 10^6 \times 15 \times 10^{-12} \times 79{,}34$

$= 16{,}4$ mA $\checkmark$ (3)

[20]

QUESTION 3

3.1
- Making the transformer window long and narrow
- Arranging the primary and secondary windings concentrically
- Sandwiching the primary and secondary windings
- Using shell-type construction (4)

3.2 3.2.1 $S = 2800 < 0 \times 1000 < -36,87$

$= 2800 < -36,87$ kVA ✓

TRF A

$P = I\,V\,COS\,\phi$

$20000 = 380 \times 330 \times COS\,\phi$

$COS\,\phi = 0,159$

$\phi = 80.85$ ✓

$Ia = 380 < -80.85$

$ZA = V/I = \frac{330 < 0}{380 < -80.85} = 0,868 < 80.85$ ✓

$= 0,138 + j\,0,857$

TRF.B

$P = I\,V\,COS\,\phi$

$25000 = 380 \times 180 \times COS\,\phi$

$COS\,\phi = 0,365$

$\phi = 68,59$

$I\,B = 380 < -68,59$ ✓

$ZB = V/I = \frac{180 < 0}{380 < -68,59} = 0,47 < 68,59$ ✓

$= 0,17 + j\,0,44$

$ZA + ZB = 0,138 + j\,0,857 + 0,17 + j\,0,44$

$= 0,31 + j\,1,3$

$= 1,34 < 76,59$ ✓

$ZT = \frac{ZA \times ZB}{ZA + ZB} = \frac{0,868 < 80.85 \times 0,47 < 68,59}{1,34 < 76,59}$

$= 0,3 < 72,85$ ✓

$VD = IL \times ZT$
$= 1000 < -36,87 \times 0,3 < 72,85$

$= 300 < 35,98$ ✓ $= 242,77 + j176,25$

$VS = V\text{(NO LOAD)} - VD$ ✓
$= 2800 < 0 - 300 < 35,98$
$= (2800 + j0) - (242,77 + j176,25) = 2800 + j0 - 242,77 - j176,25$
$= 2557,23 - j176,25$
$= 2563,3 < -3,94$ ✓ (10)

3.2.2 $S = VS \times I\text{(LOAD)}$
$= 2563,3 < -3,94 \times 1000 < -36,87$
$= 2563,3 < -40,8$ kVA ✓

$SA = \frac{S \times ZB}{ZA + ZB} = \frac{2563,3 < -40,8 \times 0,47 < 68,59}{1,34 < 76,59}$

$= 899,07 < -48,8$ kVA ✓

$\cos\phi = 0,66$ lagging ✓ (3)

3.2.3 $SB = = \frac{S \times ZA}{ZA + ZB} = \frac{2563,3 < -40,8 \times 0,868 < 80.85}{1,34 < 76,59}$ ✓

$= 1660,4 < -36,54$ kVA ✓

$\cos\phi = 0,8$ lagging ✓ (3)

[20]

QUESTION 4

4.1 Loop resistance $= \frac{\rho l}{a}$

$= \frac{1,7 \times 62 \times 10^5}{10^6 x\ \pi \times 0,8^2}$ ✓

$= 5,24\ \Omega$ ✓

Loop inductance $= 62\ [\ 0,05 + 0,2 \log e\ d/r]$ mH ✓

$= 62\ [\ 0,05 + 0,2 \log e\ (\ 90/0,8)]$ mH ✓

$= 61,66$ mH ✓

Total capacitance $= \frac{31}{36 \log e\ (\ \frac{d - r}{r}\ )}$

$= \frac{31}{36 \log e\ \left(\ \frac{90\ -\ 0,8}{0,8}\ \right)}$ ✓ ✓

$= 0,1918\ \mu$ F ✓ (8)

4.2 Total input power $= \frac{21500}{0,8} = 26875$ W ✓

P1 + P2 $= 26875$ ✓ ……… eqn. (1)

Tan ϕ $= \frac{\sqrt{3}\ (\ P2 - P1)}{26875}$

P2 – P1 $= \frac{26875}{\sqrt{3}}\ \frac{\sqrt{1 - \cos^2 \phi}}{\cos \phi}$ ✓

$= \frac{26875}{\sqrt{3}}\ \frac{\sqrt{1 - 0,7^2}}{0,7}$ ✓

$= 15829,78$ W ✓ ……. eqn. (2)

(1) + (2) $= 2 \times P\ 2 = 42704,78$ W ✓

P2 $= 21352,39$ W ✓

Sub in (eqn. 1) P1 $= 26875 - 21352,39$

$= 5522,6$ W ✓ (8)

4.3.1 W T $= W1 + W2$

$= 735 + 390$

$= 1125$ kW ✓ (1)

4.3.2 Tan ϕ $= \sqrt{3} \left(\frac{W1 - W2}{W1 + W2} \right)$

$= \sqrt{3} \left(\frac{735 - 390}{735 + 390} \right)$ ✓

$= \sqrt{3} \left(\frac{345}{1125} \right)$

$= 0,53$ ✓

ϕ $= 27,92$

cos ϕ $= 0,88$ ✓ (3)

[20]

QUESTION 5

5.1 No.✓
If the rotor were to run at synchronous speed, there would be no relative speed difference between the rotating magnetic field and the rotor✓, and hence no emf will be induced in the rotor✓ and therefore there will be no rotor current and no torque either.✓ (4)

5.2 5.2.1 Xs = 9,6 Ω per phase θ = 30
VP = 3430 V

$EZ = j\,EA - (EB \sin\theta + j\,EB \cos\theta)$ ✓

$= j\,3430 - (3430 \sin 30 + j\,3430 \cos 30)$

$= j\,3430 - 1715 - j\,2970,47$ ✓

$= -1715 + j\,459,53$

$= 1775,5$ V ✓

Circulating I $= \frac{Ez}{2Xs} = \frac{1775,5}{2 \times 9,6}$ ✓

$= 92,47$ A ✓ (5)

5.2.2 Terminal V/ P $= Ea \cos \frac{\theta}{2}$

$= 3430 \cos 15$ ✓

$= 3313{,}13$ V ✓ (2)

5.2.3 $P = \sqrt{3}\ IL\ VL$

$VL = \sqrt{3}\ VP$

$= \sqrt{3} \times 3313{,}13$

$= 5738{,}5$ V ✓

$= \sqrt{3} \times 92{,}47 \times 5738{,}5$ W ✓

$= 919{,}093$ kW ✓ (3)

5.3 5.3.1 VL = 520 N = 1000 r / min f = 50

$f = N p / 60$

$50 = \frac{1000 \times p}{60}$

$p = 3$ ✓

no of poles $= 3 \times 2 = 6$ ✓ (2)

5.3.2 No of slots per phase $= 2 \times 6 = 12$

No of conductors per phase $= 12 \times 4$

$= 48$ ✓

EMF per phase $= \frac{645}{\sqrt{3}}$

$= 372{,}4$ ✓

$Ep = 2{,}22\ kd\ kp\ \phi\ f\ Z / ph$

$372{,}4 = 2{,}22 \times 0{,}96 \times 1 \times \phi \times 50 \times 48$ ✓

$\phi = \frac{372{,}4}{2{,}22 \times 0{,}96 \times 1 \times 50 \times 48}$

$\phi = 0{,}073$ Wb

$= 73$ mWb ✓ (4)

[20]

TOTAL: 100

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