higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

ELECTROTECHNICS N5

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This marking guideline consists of 8 pages.

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QUESTION 1

1.1 The terminal voltage drops because of the resistance loss in the armature circuit✓ and the decrease in shunt current.✓ (2)

1.2
- A lap wound is used for low voltage and high current.
- A wave wound is used for high voltage and low current. (2)

1.3 $R_{ST} = V/I_1 - R_a = (220/65) - 0,4 = 2,985\ \Omega$✓

$Y = I_{min}/I_{max} = 40/65 = 0,615$✓

$1/Y = \sqrt[m]{V/IR}$
$1/0,615 = \sqrt[m]{220/(65 \times 0,4)}$✓
$(1,626)^m = 8,462$✓
$m \ln 1,626 = \ln 8,462$✓
$m = \ln 8,462/\ln 1,626$✓
$= 2,136/0,486$
$= 4,395$
$= 4$ sections✓ (7)

1.4 $E_1 = V - I_{a1}(R_a + R_{se})$
$= 240 - 84(0,46 + 0,34)$
$= 172,8$ V✓

$T \alpha N$
$\phi \alpha I_{se}$

$T_2/T_1 = \phi_2 I_{a2}/\phi_1 I_{a1}$
$770/900 = (I_{se2} I_{a2})/(84 \times 84)$✓
$(I_{a2})^2 = 6\ 036,8$✓
$I_{a2} = \sqrt{6\ 036,8}$
$= 77,697$ A✓

$E_2/172,8 = (77,697 \times 770)/(84 \times 900)$✓
$E_2 = 136,748$ V✓

$E_2 = V - I_{a2}(R_a + R_{se} + R_X)$
$136,748 = 240 - 77,697(0,46 + 0,34 + R_X)$✓
$0,8 + R_X = 1,329$ ✓
$R_X = 1,329 - 0,8$
$= 0,529\ \Omega$✓ (9)
[20]

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QUESTION 2

2.1 $P = V\,I\cos\theta$

$\cos\theta = P/V\,I$

$= 1\,400/(230 \times 6{,}5)$

$= 0{,}936$✓

$\theta = \cos^{-1}(0{,}936)$

$= 20{,}61$✓

$Z_1 = 230 < 0/6{,}5 < -20{,}61$

$= 3{,}077 < 20{,}61\ \Omega$✓

$= 2{,}88 + j1{,}083$

$I_2 = I_T - I_1$

$= 15{,}66 - j8{,}875 - 6{,}083 + j2{,}288$✓

$= 9{,}577 - j6{,}587$

$= 11{,}624 < -34{,}52$ A✓

$Z_2 = 230 < 0/11{,}624 < -34{,}52$

$= 19{,}787 < 34{,}52\ \Omega$✓

$= 16{,}303 + j11{,}213$

Series circuit:

$Z_T = Z_1 + Z_2$

$= 2{,}88 + j1{,}083 + 16{,}303 + j11{,}213$✓

$= 19{,}183 + j12{,}296$

$= 22{,}786 < 32{,}66\ \Omega$✓

$I_T = 230 < 0/22{,}786 < 32{,}66$

$= 10{,}094 < -32{,}66$ A✓

$\cos\theta = \cos 32{,}66$

$= 0{,}849$✓ (10)

2.2 2.2.1 $Z_1 = 5 < 53,13\ \Omega$
$Z_2 = 10,77 < 68,19\ \Omega$
$Z_3 = 8,544 < -20,56\ \Omega$

$Z_P = Z_2\ Z_3/(Z_2 + Z_3)$
$= 10,77 < 68,19 \times 8,544 < -20,56/(4 + j10 + 8 - j3)$✓
$= 92,019 < 47,63/(12 + j7)$
$= 6,624 < 17,37\ \Omega$✓
$= 6,322 + j1,978$

$Z_T = Z_1 + Z_P$
$= 3 + j4 + 6,322 + j1,978$✓
$= 9,322 + j5,978$
$= 11,074 < 32,67\ \Omega$✓

$I_T = 120 < 0/11,074 < 32,67$
$= 10,836 < -32,67\ A$✓

$V_{SE} = I_T\ Z_1$
$= 0,836 < -32,67 \times 5 < 53,13$✓
$= 54,18 < 20,46\ V$✓ (7)

2.2.2 $V_P = I_T\ Z_P$
$= 10,836 < -32,67 \times 6,624 < 17,37$✓
$= 71,778 < -15,3\ V$✓ (2)

2.2.3 $\cos \theta = \cos 32,67$
$= 0,842$ lagging✓ (1)
[20]

QUESTION 3

3.1 Laminating the iron core (1)

3.2
- Making the transformer window long and narrow
- Arranging the primary and secondary windings concentrically
- Sandwiching the primary and secondary windings
- Using a shell-type construction (Any 2 × 1) (2)

3.3 $Z_1 = (5 + j8)\ 1{,}211$
$= 6{,}055 + j9{,}688$
$= 11{,}425 < 57{,}99\ \Omega$✓

$Z_2 = 3{,}8 + j6$
$= 7{,}102 < 57{,}65\ \Omega$✓

$Z_1 + Z_2 = 6{,}055 + j9{,}688 + 3{,}8 + j6$
$= 9{,}855 + j15{,}688$
$= 18{,}527 < 57{,}86\ \Omega$✓

$\theta = \cos 0{,}87$
$= 29{,}54°$

$S_T = P_T/\cos\theta$
$= 1\ 500/0{,}87$
$= 1\ 724{,}138$ kVA✓

$S_1 = S_T\ Z_2/(Z_1 + Z_2)$
$= 1\ 724{,}138 < -29{,}54 \times 7{,}102 < 57{,}65/18{,}527 < 57{,}86$✓
$= 12\ 244{,}828 < 28{,}11/18{,}527 < 57{,}89$
$= 660{,}918 < -29{,}75$ kVA✓

$Pf = \cos 29{,}75$
$= 0{,}868$ lagging✓

$S_2 = 1\ 724{,}138 < -29{,}54 \times 11{,}425 < 57{,}99/18{,}527 < 57{,}86$✓
$= 19\ 698{,}277 < 28{,}45/18{,}527 < 57{,}86$
$= 1\ 063{,}22 < -29{,}41$ kVA✓

$Pf = \cos 29{,}41$
$= 0{,}871$ lagging✓ (10)

3.4 $Z_{E1} = 0{,}43 + j1{,}95$
$= 1{,}997 < 77{,}56\ \Omega$✓

$Z_2 = 50 + j80$
$= 94{,}339 < 57{,}99\ \Omega$✓

$I_2 = V_2/Z_2$
$= 230/94{,}339$
$= 2{,}438$ A✓

$I_1 = I_2\ V_2/V_1$
$= (2{,}438 \times 230)/480$
$= 1{,}168$ A✓

$Reg = 1{,}997 \times 1{,}168 \cos (77{,}56 - 57{,}99)/480$✓
$= 2{,}198/480$
$= 0{,}00458 \times 100$
$= 0{,}458\%$✓ (6)

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3.5 Voltage regulation is the change in secondary terminal voltage from no-load to full-load while applied voltage remains constant. (1)
[20]

QUESTION 4

4.1
$$\tan \theta = \sqrt{3}\,(P_2 - P_1)/(P_1 + P_2)$$
$$= \sqrt{3}\,(4{,}4 \times 10^3 + 660)/(4{,}4 \times 10^3 - 660)\checkmark$$
$$= 8\,764{,}177/3\,740$$
$$= 2{,}343\checkmark$$

$$\theta = \tan^{-1}(2{,}343)$$
$$= 66{,}89°\checkmark$$

$$Pf = \cos 66{,}89$$
$$= 0{,}392\checkmark$$ (4)

4.2 4.2.1
$$I_P = S/(\sqrt{3}\,V_L)$$
$$= 3{,}5 \times 10^6/(\sqrt{3} \times 13 \times 10^3)$$
$$= 155{,}44\ A\checkmark$$

$$V_r = 13\,000/\sqrt{3}\,(\cos\theta + j\sin\theta)$$
$$= 7\,505{,}553\,(0{,}79 + j0{,}613)$$
$$= 5\,929{,}387 + j4\,600{,}904\checkmark$$

$$V_d = I_P Z_P$$
$$= 155{,}44\,(8 + j12)$$
$$= 1\,243{,}52 + j1\,865{,}23\checkmark$$

$$V_S = V_r + V_d$$
$$= 5\,929{,}387 + j4600{,}904 + 1\,243{,}52 + j1\,865{,}23$$
$$= 7\,172{,}907 + j6\,466{,}134\checkmark$$
$$= 9\,657{,}199 < 42{,}03\ V\checkmark$$

$$V_{S\,LINE} = \sqrt{3} \times 9\,657{,}199$$
$$= 16\,726{,}759\ V$$
$$= 16{,}727\ kV$$

$$Reg = (V_S - V_r)/V_r$$
$$= (9\,657{,}199 - 7\,505{,}553)/7\,505{,}553\checkmark$$
$$= 0{,}287 \times 100$$
$$= 28{,}667\%\checkmark$$ (7)

OR

$$Reg = (16\,726{,}759 - 13\,000)/13\,000\checkmark$$
$$= 0{,}287 \times 100$$
$$= 28{,}667\%\checkmark$$

4.2.2 $P_O = (3{,}5 \times 10^6 \times 0{,}79)/3$
$= 921\,666{,}667$ W
$= 921{,}667$ kW✓

$P_{LOSS} = I^2 R$
$= 155{,}44^2 \times 8$
$= 193{,}293$ kW✓

$P_{IN} = P_O + \text{loss}$
$= 921{,}667 + 193{,}293$
$= 1\,114{,}96$ kW✓

$\eta = P_O/P_{IN}$
$= 921{,}667/1\,114{,}96$
$= 82{,}66\%$✓ (4)

4.3 4.3.1 $d_e = 100 \times 140 \times 210$
$= 143{,}257$ cm✓

$L = 30[0{,}05 + 0{,}2 \ln(143{,}257/0{,}3)]$✓
$= 30(0{,}05 + 1{,}234)$
$= 38{,}512$ mH✓ (3)

4.3.2 $C = 30[18 \ln(143{,}257/0{,}3)]$✓
$= 30/111{,}035$
$= 0{,}27$ µF✓ (2)
[20]

QUESTION 5

5.1 5.1.1 The ratio between emf induced with a short-pitched coil and the emf induced with a full-pitch coil

5.1.2 The ratio between emf induced with a distributed winding and the emf induced with a concentrated winding

5.1.3 The ratio between the effective value of emf and the average value of emf

(3 × 2) (6)

5.2 5.2.1

$$f = N_S P/60$$
$$50 = (N_S \times 3)/60$$
$$N_S = (60 \times 50)/3 \checkmark$$
$$= 1\,000 \text{ r/min} \checkmark$$

(2)

5.2.2

$$S = (N_r - N_S)/N_S$$
$$0{,}06 \times 1\,000 = N_r - 1\,000 \checkmark$$
$$N_r = 1\,000 + 60$$
$$= 1\,060 \text{ r/min} \checkmark$$

(2)

5.2.3

$$f = (N_S - N_r)\,P/60$$
$$= (1\,000 - 600) \checkmark \times 3/60 \checkmark$$
$$= 20 \text{ Hz} \checkmark$$

(3)

5.3

$$E_P = 415/\sqrt{3}$$
$$= 239{,}6 \text{ V} \checkmark$$

$$F = NP/60$$
$$P = 60f/N$$
$$= (60 \times 50)/1\,500$$
$$= 2 \text{ (pairs)} \checkmark$$
$$= 4 \text{ poles} \checkmark$$

$$\text{Slots} = 8 \times 4 \times 3$$
$$= 96 \checkmark$$

$$Z_P = (16 \times 96)/3$$
$$= 512 \text{ cond/ph} \checkmark$$

$$E_P = 2{,}22\, K_d\, K_P\, \phi\, f\, Z_P$$
$$239{,}6 = 2{,}22 \times 0{,}96 \times \phi \times 50 \times 512 \checkmark$$
$$\phi = 239{,}6/55\,013{,}376$$
$$= 4{,}355 \text{ mwb} \checkmark$$

(7)
[20]

TOTAL: 100

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