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 Series-wound motors are suitable for use in:
- Cranes
- Trains
- Trams
- Motor vehicle starters and
- Gate motors (Any 4 × 1) (4)

1.2
- Lap wound – for low voltage and high current
- Wave wound – for high voltage and low current (2)

1.3 1.3.1 $E_1 = V - I_a R_a$ (motor)

$= 260 - (60)(0,25)$✓
$= 260 - 15$
$= 245\ V$✓

$$\frac{E2}{E1} = \frac{N2}{N1}$$

$$E_2 = 245 \times \frac{900}{1100}$$

$= 200,45\ V$✓

$E_2 = V - I_a(R_a - x)$
$200,45 = 260 - 60(0,25 + x)$
$200,45 = 260 - 15 - 60x$
$x = 0,743\ \Omega$✓ (5)

1.3.2 $T_2/T_1 = 0,5\ I_{a2}/I_{a1}$✓
$I_{a2} = 0,5I_{a1} = 30\ A$✓
$E_2 = V - I_{a2}R_a = 260 - 30(0,25) = 252,5\ V$✓

$$\frac{E2}{E1} = \frac{N2}{N1}$$

$$N_2 = \frac{E2}{E1} \times \frac{N1}{1} = 252,5 \times \frac{1100}{245}$$✓ $= 1133,67$ r/min✓ (5)

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1.4 At/p = (7 – 5,5) × 1 800✓ = 2 700 At/p✓

For series winding = $\frac{2700}{343,74}$ ✓= 8✓

OR

At/p = (7 – 5,5) × 1 800 = 2 700 At/p

IL = p/V

= 115 000 / 340

= 338,235 A

Ia = 5,5 + 338,235

= 343,74 A

Turns = 2 700 / 343,74
= 8 (Any 1 × 4) (4)
[20]

QUESTION 2

2.1 C_1 = 360 × 10^{-12} F (I_{max})
C_2 = 340 × 10^{-12} F ($I_2 = 0,707I_{max}$)✓

$X_{c1} = \frac{1}{2\pi fC1} = \frac{1x10\ \exp -12}{2\pi x,75x10exp6x360}$ = 589,76 Ω

$X_{L1} = X_{L2}$ = 589,76 Ω (resonance)✓

$L = \frac{XL}{2\pi f} = \frac{589,76}{2\pi x.75x10exp6}$ = 125,087 µH✓

$X_{c2} = \frac{1}{2\pi fC2} = \frac{10\ \exp 12}{2\pi x.75x10exp6x340}$✓ = 624,14 Ω✓

Increase in X_c = 624,14 – 589,76 = 34,38 Ω✓

$(Z_2)^2 = R^2 + (34,38)^2$ ✓

$Z_2 = \sqrt{\{(R^2 + (34,38)^2\}}$

$I_1 = \frac{V}{Z1}$ and $I_2 = 0,707I_1$ and Z_1 = R (resonance)

$\frac{0,707V}{Z1} = \frac{V}{Z2}$

$\frac{0,707}{R} = \frac{1}{\sqrt{\{(R2 + (34,38)2\}}}$ ✓

$(R^2 + (34,38)^2 = 2R^2$

$2R^2 – R^2 = (34,38)^2$ ✓

$R^2 = (34,38)^2$

R = 34,38 Ω ✓ (10)

2.2 2.2.1 $X_L = 2\pi fL = 2\pi(2,2 \times 10^6 \times 350 \times 10\text{-}^6$)✓
= 4838,1 Ω✓

$f_{res} = \frac{1}{2\pi\sqrt{(LC)}}$

$2,2 \times 10^6 = \frac{1}{2\pi\sqrt{(350x10exp-6xC)}}$ ✓

$350 \times 10^{-6} \times C = \frac{1}{(2x\pi x2,2 \text{ x } 10exp6\ )2}$ ✓

$C = 1,5 \times 10^{-11} = 15 \times 10^{-12}$ F✓

OR

$X_L = 2\pi fL = 2\pi(2,2x10^6 \times 350 \times 10\text{-}^6$)
= 4838,053 Ω

XL = Xc
4838,053 = 1 / 2π×2,2$x\ 10^6$C
C = 14,952pf (Any 1 × 5) (5)

2.2.2 $Z_p = \frac{L}{CR} = \frac{350 \exp -6}{15 \exp -12\ x30}$✓ = 777,777 kΩ✓ (2)

2.2.3 $I_t = \frac{Vt}{Zt} = \frac{80}{784277,778}$ = 0,102 mA

$V_L = I_t \times Z_p = 0,102 \times 1,0^{-3} \times 777777 = 79,336$ V✓

$I_{coil} = \frac{VL}{ZL} = \frac{79,336}{30+j4838,053}$ = 16,4 mA✓ **OR** 0,016 A

$I_c = 2 \times \pi \times 2,2 \times 10^6 \times 1,5 \times 10^{-11} \times 79,336$ =16,4 m A✓ **OR** 0,016 A (3)
[20]

QUESTION 3

3.1 3.1.1 $V_{p1} = \frac{VL}{\sqrt{3}} = \frac{3\,400}{\sqrt{3}}$ = 1 963 V✓

$V_{p2} = V_{p1} \times \frac{N2}{N1}$ = 1 963 x $\frac{60}{510}$✓ = 230,9 V secondary line voltage✓ (3)

3.1.2 V_{p1} = 3 400 V✓

$V_{p2} = V_{p1} \times \frac{N2}{N1}$ = 3 400 × $\frac{60}{510}$ = 400 V✓

V_{L2} = 400 x $\sqrt{3}$ = 692,8 V✓ (3)

3.2 3.2.1 R_e = 0,8 + 0,06$(\frac{450}{130})^2$ = 1,52Ω✓

X_e = 1,7 + 0,07$(\frac{450}{130})^2$ = 2,54 Ω✓

$Z_e = \sqrt{(1{,}52^2 + 2{,}54^2)}$ = 2,96 Ω✓

OR

Ze = Re +jXe =1,52+j 2,54 = 2,96∠59,102 (3)

3.2.2 Cos ∅ = 0,9 and sin∅ = 0,436✓

$I_{1(full\ load)} = \frac{S}{V} = \frac{245\,000}{2650}$ = 92,45 A✓

$V_{reg\ (0,9\ lagging)} = \frac{I1(Re\ cos\emptyset + Xe\ sin\emptyset)}{V1}$ ✓= $\frac{92{,}5(1{,}52x0{,}9 + 2{,}54x0{,}436)}{2650}$ = 0,086 pu✓

$V_{no\ load}$ = 2 650 x $\frac{130}{450}$ = 765,56 V✓

Decrease of V_2 (between no load and full load)
= 765,56 x 0,086 = 65,84 V✓
V_{FL} = 765,56 – 65,84 = 699,7 V✓

$V_{reg\ (0,9\ leading)} = \frac{I1(Re\ cos\emptyset - Xe\ sin\emptyset)}{V1} = \frac{92{,}5(1{,}52x0{,}9 - 2{,}54x0{,}436)}{2\,650}$ = 0,009 pu✓

$V_{no\ load}$ = 2 650 x $\frac{130}{450}$ = 765,56 V✓

Increase in V_2 (between no load and full load)
= 765,56 × 0,009 = 6,89 V✓
V_{FL} = 765,56 +6,89 = 772,45V✓ (11)
[20]

QUESTION 4

4.1 $I_L = \frac{P}{\sqrt{3}xVLxcos\emptyset} = \frac{820000}{\sqrt{3}x33000x0,8}$✓ = 17,93 A✓

$V_s = V_r\angle\emptyset$ + IR∠0°+IX∠90°=19 052,56∠36,87° +
17,93 × 40∠0° + 17,93 × 70∠90°
= 19 052,56∠36,87° + 717,2∠0° + 1 255,1∠90°✓
= (15 242 + j 11 431,56) + (717,2 + j 0) + (0 +j 1255,1) ✓
= 1 559,2 + j 12 686,1
= 20 387 ∠38,48° V✓

V_L = Vp × √3 = 20 387 × √3 = 35 311,32 V✓

%Reg = $\frac{Vs-Vr}{Vr}$ × 100% = $\frac{20387-19052,56}{19052,56}$ × 100%✓ = 7% = 0,007 pu✓

OR

Vdrop = IR+jIx
= 17,933 (40 + j70)✓
= 717,32 + j1255,31
= 1 445,805∠60,255°

Vs = Vr (Cosø + j Sinø)+ Vdrop
= 19 052,559 (0,8 + j0,6) +717,32 + j1255,31✓
= 15 959,367 + j 12 686,845✓
= 20 387,678 ∠ 38,483° V✓ (8)

4.2 *Tan ø* = $\frac{\sqrt{3}(W2-W1)}{(W2+W1)} = \frac{\sqrt{3}(1\,200-650)}{(1\,200+650)} = \sqrt{3}\,\frac{550}{1\,850}$ *= 0,515*✓

ø = 27,25°✓
Pf = Cos27,25 = 0,89✓
$I_L = \frac{Pt}{\sqrt{3}Vl\,cos\emptyset} = \frac{1\,850}{\sqrt{3}(150)(0,89)}$ *= 8 A*✓

OR

Ip = Wt/ 3 vpCosø =1 850/ 3×150×0,89 = 4,62 A✓

$I_p = \frac{IL}{\sqrt{3}} = \frac{8}{\sqrt{3}}$ = 4,62 A✓

Z = $\frac{V}{I} = \frac{150}{4,62}$ = 32,47 Ω✓ (6)

4.3 $P_t = W_2 + W_1$ = 920 + 295 = 1 215 W✓

Tan ø = $\frac{\sqrt{3}(W2-W1)}{W2+W1)(} = \frac{\sqrt{3}(920-295)}{(920+295)}$✓ = $\sqrt{3}\,\frac{625}{1215}$ =0,891✓

ø = 41,7°

Cos ø = 0,747✓ (4)

4.4 Voltage regulation is the rise or fall in the receiving end voltage of transmission lines when full load is switched off,✓ provided that the sending end voltage remains constant.✓ (2)
[20]

QUESTION 5

5.1 5.1.1 $N_s = \frac{60f}{p}$✓ = $\frac{60(50)}{2}$✓ = 1 500 r/min✓

OR

Ns = f/p = 50/2 = 25r/s (Any 1 × 3) (3)

5.1.2 $N_r = N_s – sN_s$ = 1500✓– (0,075) x 1 500✓ = 1 387,5 r/min✓

OR

0,075 = 25 - Nr/Ns
1,875 = 25-nr
Nr = 23,125r/s (Any 1 × 3) (3)

5.1.3 Fr = s.f
= 0,075 × 50✓
= 3,75 Hz✓ (2)

5.2 5.2.1 Z = 0,8 + j 9,5
$E_A = E_B$ = 2100 V
E_Z = jE_A – (E_B sinØ-j E_B cosØ)✓
= j 2 100 – (2 100 sin 40° - j2 100 cos 40°)✓
= j 2 100 – (1 349,853 +j1 608,693)
= - 1 349,853 + j491,307✓
= 1 436,484∠160° V✓

I = $\frac{Ez}{2Xs}$ = $\frac{1436,484\angle 160}{2(9,534)}$✓= 75,335∠ 74,14°V✓

OR

ER = Ea∠0 + EB ∠ 180- Ø
$= 2\,100\angle 0 + 2\,100\angle 180 - 40$
$= 2\,100\angle 0 + 2\,100\angle 140$
$= 1\,436{,}485\angle 70$ V
$= 491{,}306 + j1349{,}854$ V

Ic = ER/2Z
= 1 436,485∠70/19,067∠85,186
$= 75{,}343\angle -15{,}186$ A

OR

Zt = Z1 + Z2
= 1,6 + j19
= 19,067∠85,186

Es = Ea + Eb
= 2 100∠90 + 2 100∠-130
= -1 350 + j 491,3
= 1 436,6∠160

Is = Es/Zt
= 1 436,6∠160 / 19,067∠ 85,186
= 75,345∠74,814 A

(Any 1 × 6) (6)

5.2.2 $V = E_A \cos(\frac{\emptyset}{2})$ = 2 100 cos 20°✓ = 1 973,35 V✓

OR

$TV = Ea\angle 0 - \frac{1}{2} ER$
$= 2\ 100\angle 0 - 1\ 436{,}485\angle 70/2$
$= 2\ 100\angle 0 - 718{,}243\angle 70$
$= 1\ 973{,}354\angle -20$ V✓

OR

Vp = Ea+Eb / 2
= 2 100∠ 90 + 2 100 ∠ 50 / 2
= 1 349,85+j3 708,69 / 2
= 3 946,7∠70/ 2
= 1 973,35∠70

(Any 1 × 2) (2)

5.2.3 P = VI = 1973,35 × 75,335✓ = 148,662 kW✓

OR

$P = VI\cos\emptyset$
$= 1\ 973{,}354 \times 75{,}343 \times 0{,}996$
$= 148{,}154$ kW

$= \cos(\emptyset Ic - \emptyset Tv)$
$= \cos(-15{,}186-(-20))$
$= 0{,}996$

OR

P = VIcosØ
= 1 973,35 × 75,345 × cos(74,814-70)
= 148,158 Kw

(Any 1 × 2) (2)

5.3 Slip is the difference between the synchronous speed of the magnetic field✓ and the actual speed of the rotor in an induction motor.✓ (1 × 2) (2)

[20]

TOTAL: 100

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