higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

APRIL EXAMINATION

ELECTROTECHNICS N6

8 APRIL 2016

This marking guideline consists of 9 pages.

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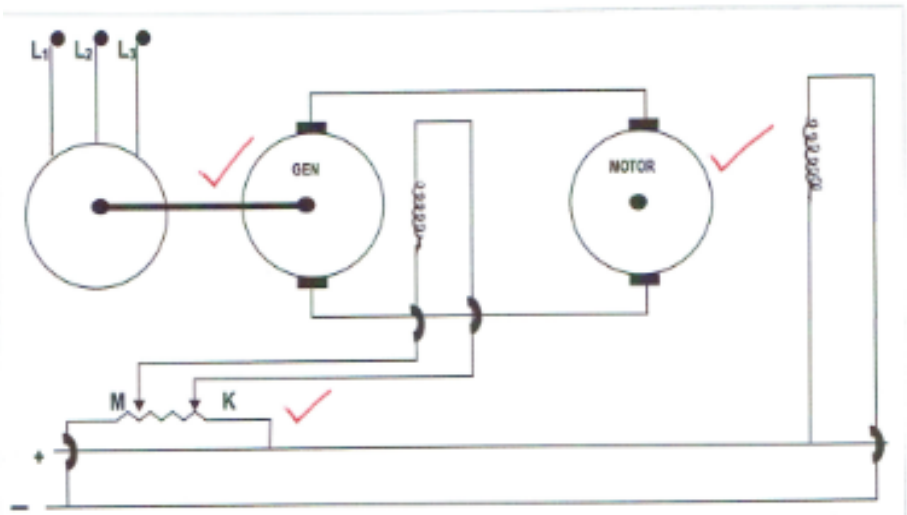
QUESTION 1

1.1

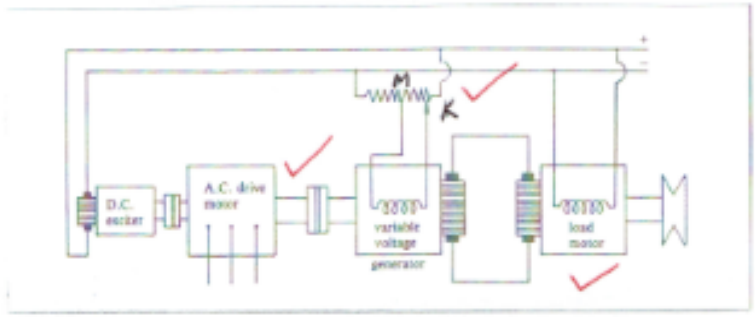


(3)

- *The excitation of the motor is constant*
- *Control is obtained by adjusting the field current of generator by means of the potentiometer*
- *Potentiometer can be adjusted from zero to maximum by moving K.*
- *Direction can be reversed by connecting K to the left of M.*

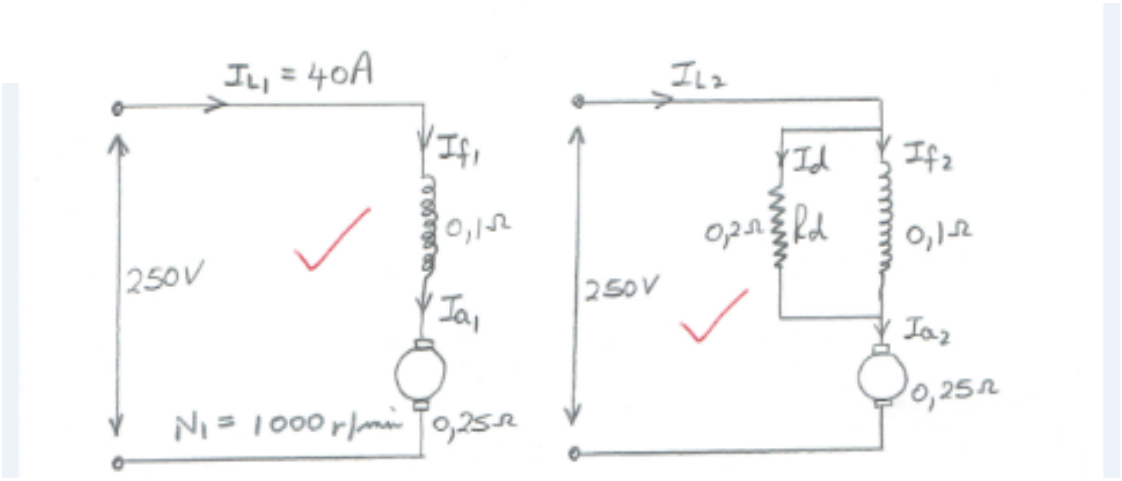
(4)

ALTERNATE SOLUTION



(3)

1.2



(2)

1.3 $R_{ac1} = 0,1 + 0,25 = 0,35\ \Omega$✓

$E_1 = 250 - (40)(0,35) = 236$ V✓

$R_{ac2} = 0,25 + \frac{(0,2)(0,1)}{0,2+0,1} = 0,317\ \Omega$✓

$I_{f2} = \left(\frac{0,2}{0,2+0,1}\right) I_{a2} = 0,667\ I_{a2}$✓

$$\frac{T_1}{T_2} = \frac{I_{a1} I_{f1}}{I_{a2} I_{f2}}$$

$$\frac{T_1}{1,2T_1} = \frac{(40)(40)}{I_{a2}(0,667\ I_{a2})}$$✓

$$I_{a2} = \sqrt{\frac{(1,2)(40 \times 40)}{0,667}} = 53,652\ A$$✓

$$I_{f2} = (0,667)(53,652) = 35,786\text{A}$$✓

$E_2 = 250 - (53,652)(0,317) = 232,992$ V✓

$$N_2 = \frac{E_2 N_1 I_{f1}}{E_1 I_{f2}} = \frac{(232,992)(1\,000)(40)}{(236)(35,786)}$$✓ $= 1\,103,509\ r/min$ ✓

(10)
[19]

QUESTION 2

2.1

FUNDAMENTAL	THIRD HARMONIC
$R_1 = 180\,\Omega$	$R_3 = 180\,\Omega$
$X_{c1} = \frac{1}{\omega c} = 127{,}389\,\Omega$ ✓	$X_{c3} = \frac{X_{c1}}{3} = 42{,}463\,\Omega$ ✓
$Z_A = 180 + j\,0 = 180 \angle 0^\circ$	$Z_A = 180 + j\,0 = 180 \angle 0^\circ$
$Z_B = 0 - j\,127{,}389 = 127{,}389 \angle -90^\circ$	$Z_B = 0 - j\,42{,}463 = 42{,}463 \angle -90^\circ$
$Z_A + Z_B = 180 - j\,127{,}389$	$Z_A + Z_B = 180 - j\,42{,}463$
$= 220{,}517 \angle -5{,}288^\circ$	$= 184{,}941 \angle -13{,}274^\circ$
$Z_1 = \frac{Z_A \times Z_B}{Z_A + Z_B}$	$Z_3 = \frac{Z_A \times Z_B}{Z_A + Z_B}$
$= \frac{22\,930{,}02 \angle -90^\circ}{220{,}517 \angle -35{,}288^\circ}$	$= \frac{7\,643{,}34 \angle -90^\circ}{184{,}941 \angle -13{,}274^\circ}$
$= 103{,}983 \angle -54{,}712^\circ$ ✓	$= 41{,}329 \angle -76{,}726^\circ$ ✓

$$i = \frac{30}{103{,}983}\sin[314t + 25^\circ - (-54{,}712^\circ)] ✓ + \frac{10}{41{,}329}\sin[942t - 30^\circ - (-76{,}726)] ✓$$

= 0,289 sin(314t + 79,712˚) ✓ + 0,242 sin(942t + 46,726˚) ✓ A (8)

2.2

$$V_{RMS} = \sqrt{\frac{30^2 + 10^2}{2}} = 22{,}361\,V ✓$$

$$I_{RMS} = \sqrt{\frac{0{,}289^2 + 0{,}242^2}{2}} = 0{,}267\,A ✓$$

$$P = \frac{(30)(0{,}289)}{2}\cos(-54{,}712^\circ) + \frac{(10)(0{,}242)}{2}\cos(-76{,}726^\circ)$$

= 2,504 + 0,278

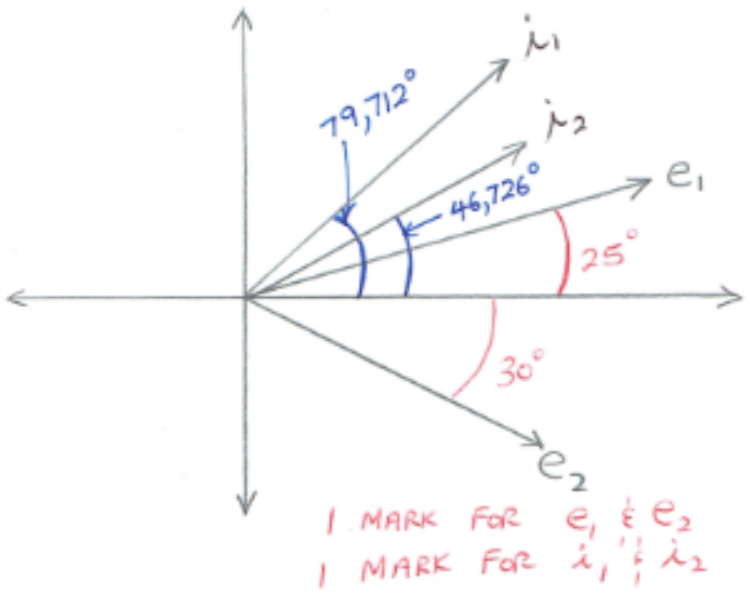
= 2,782 W ✓

$$\cos\emptyset = \frac{P}{V_{RMS} I_{RMS}} = \frac{2{,}782}{(22{,}361)(0{,}267)} ✓ = 0{,}466\ leading ✓$$

(5)

2.3 Energy = P.t = (2,782)(10× 10^{-3}) = 0,028 J✓ (1)

2.4



(2)
[16]

QUESTION 3

3.1
- Eddy current losses✓ in the iron core✓
- Di-electric losses✓ in the insulating material✓
- Hysteresis losses in the iron parts (Any 2 x 2) (4)

3.2 3.2.1

$$\eta_{Max} = \frac{kS\cos\emptyset}{kS\cos\emptyset + 2P_o} \times 100\%$$

$$0{,}92 = \frac{(0{,}8)(250)(0{,}85)}{(0{,}8)(250)(0{,}85) + 2P_o} \checkmark$$

$$= \frac{170}{170 + 2P_o}$$

P_o = 7,391 kW ✓ (2)

3.2.2 $k = \sqrt{\frac{P_o}{P_{sc}}}$ $P_{sc} = \frac{P_o}{k^2} = \frac{7{,}391}{0{,}8^2}$ ✓ = 11,548 kW✓ (2)

3.2.3 $I_1 = \frac{S}{V_1} = \frac{250\,000}{3\,300} = 75{,}758\ A$✓

$P_{sc} = I_1^2 R_{e1}$ $R_{e1} = \frac{11\,548}{75{,}758^2} = 2{,}012\ \Omega$✓

$\%R = \frac{I_1 R_{e1}}{V_1} \times 100\% = \frac{(75{,}758)(2{,}012)}{3\,300} \times 100\%$✓ = 4,619 %✓ (4)

3.2.4 P/u regulation = $\frac{I_1[R_{e1}\cos\emptyset + X_{e1}\sin\emptyset]}{V_1} = \frac{75{,}758[(2{,}012)(1)+0]}{3\,300}$ ✓ = 0,046✓ (2)

[14]

QUESTION 4

4.1 It is the ratio✓ of the actual EMF obtained✓ to the EMF that would be obtained if all the conductors were concentrated in one slot only.✓ (3)

4.2 $E_P = \frac{3\,300}{\sqrt{3}}$ = 1 905,256 V ✓

$f = \frac{Np}{60}$ $p = \frac{(60)(50)}{1\,000} = 3$ $\therefore$ 6 poles✓

Total slots = (4)(6 poles)(3 phases) = 72 ✓

$\varphi = 180° - 150° = 30°$ ✓

$k_p = \cos\frac{\varphi}{2} = \cos\frac{30°}{2} = 0{,}966$ ✓

$\gamma = \frac{180°}{4\times3}$ = 15˚ ✓

$k_d = \frac{\sin\frac{\eta\gamma}{2}}{\eta\sin\frac{\gamma}{2}} = \frac{\sin\frac{(4)(15°)}{2}}{4\sin\frac{15°}{2}} = 0{,}958$✓

$E_p = 4f\emptyset T_p k_f k_p k_d$

$T_p = \frac{1\,905{,}256}{(4)(50)(55\times10^{-3})(1{,}11)(0{,}966)(0{,}958)}$ ✓ = 168,615✓

$Z_p = 168{,}615 \times 2 = 337{,}23$✓

$Z_T = 337{,}23 \times 3 = 1\,011{,}69$✓

$\therefore$ Conductors per slot $= \frac{1\,011{,}69}{72} = 14{,}051$ say 14✓ (12)

[15]

QUESTION 5

5.1 $V_p = \frac{380}{\sqrt{3}} = 219{,}393\ V$✔

$E_p = \frac{500}{\sqrt{3}} = 288{,}675\ V$ ✓

$Z_s = (1{,}5 + j\ 4{,}8) = 5{,}029 \angle 72{,}646^\circ$ ✓

$E_R = 219{,}393 \angle 0^\circ$ ✔ + $288{,}675 \angle 155^\circ$ ✓

= (219,393 + j 0) + (-261,628 + j 122)

= -42,235 + j 122

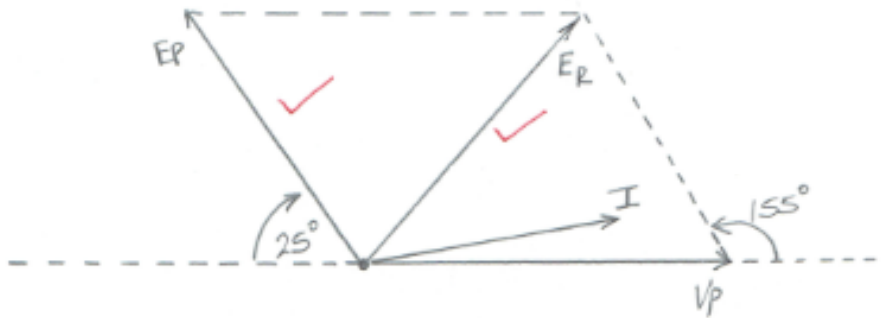
= 129,104 ∟ 109,095° ✓

$I = \frac{E_R}{Z} = \frac{129{,}104 \angle 109{,}095^\circ}{5{,}029 \angle 72{,}646^\circ} = 25{,}672 \angle 36{,}87^\circ\ A$✔ (7)

5.2 $P_i = \sqrt{3}\ V_L I_L \cos\emptyset = (\sqrt{3})(380)(25{,}672)\cos(36{,}449°)$✔ $= 13{,}592\ kW$✔

$P_o = P_i \times \eta = (13{,}592)(0{,}85) = 11{,}553\ kW$✔ (3)

5.3



(2)
[12]

QUESTION 6

6.1 $N_s = \frac{60\,f}{p} = 1\,000\,r/min$✓

$\%\,S = \frac{N_s - N}{N_s} \times 100\,\% = 5\,\%$✓ (2)

6.2 Power developed = Rotor output = 28 kW

Rotor copper loss = $Rotor\ output\left(\frac{S}{1-S}\right)$

$= 28\left(\frac{0,05}{1-0,05}\right)$ ✓

= 1,474 kW ✓ (2)

6.3 Power input = Rotor output + Rotor copper loss + Rotor iron loss + Total stator loss

= (28) + (1,474) + (0) + (1,08) ✓

= 30,554 kW✓ (2)

6.4 $P_i = \sqrt{3}\,V_L I_L \cos\emptyset$

$I_L = \frac{30,554 \times 10^3}{(\sqrt{3})(525)(0,8)}$ ✓ = 42 A✓ (2)

6.5 Power output = Rotor output — frictional loss

= 28 – 0,8 ✓

= 27,2 kW ✓

$\eta = \frac{P_o}{P_i} \times 100\,\% = 89,023\,\%$✓ (3)

[11]

QUESTION 7

7.1 From triangle ABC:

$\tan(41{,}41^\circ) = \frac{\overline{BC}}{750}$ ✓

$\overline{BC} = 661{,}447\ kVAr$ ✓

From triangle ABD:

$\tan(25{,}842^\circ) = \frac{\overline{BD}}{750}$ ✓

$\overline{BD} = 363{,}243\ kVAr$ ✓

Installed kVAr = $\overline{BC} - \overline{BD} = 298{,}204\ kVAr$✓ (5)

7.2 Cost of capacitor bank = (298,204)(295✓) = R 87 970✓ (2)

7.3 kVA charge before installation of capacitor bank = (1 000)(132) =R132 000 ✓

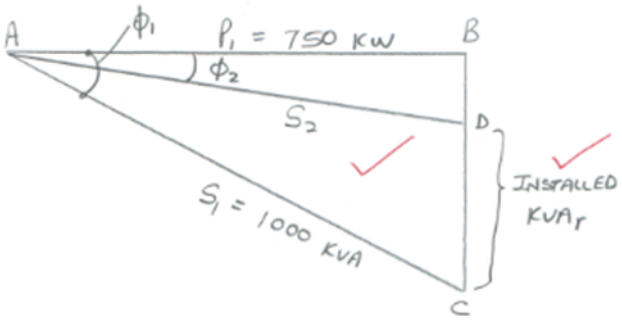
kVA after installation = $\overline{AD} = \sqrt{750^2 + 363{,}243^2}$ = 833,334 kVA ✓

kVA charge after installation of capacitor bank = (833,334)(132) = R110 000

Monthly savings in kVA charge = R132 000 – R 110 000 = R22 000✓

Number of months = $\frac{87\ 970}{22\ 000}$ = 4 ✓ (4)

7.4



(2)
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TOTAL: 100

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