201311T103

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T520(E)(N8)T
NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

ELECTROTECHNICS N4

(8080074)

8 November (X-Paper)
09:00–12:00

REQUIREMENTS: ONE Graph paper

Candidates will require drawing instruments, pens and a ruler.

Calculators may be used.

ENGINEERING

This question paper consists of 6 pages and 2 formula sheets.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ELECTROTECHNICS N4
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Write neatly and legibly.

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QUESTION 1

1.1 An aluminium conductor 500 m long is connected in parallel with a copper conductor of the same length. When a current of 150 A is passed through the combination, it is found that the current through the copper conductor is 50 A. The diameter of the aluminium conductor is 25 mm.

Determine the following:

1.1.1 The diameter of the copper conductor, if the resistivity of copper is 0,017 micro-ohm metre and that of aluminium is 0,027 micro-ohm metre

1.1.2 The voltage drop across the conductors (2 × 4) (8)

1.2 A resistance of 6 ohms is connected in parallel with a resistance of 30 ohms. The combination is connected in series with a third resistance of 3 ohms. If the whole circuit is connected across a battery having an EMF of 27 V and an internal resistance of 1 ohm,

Determine the following:

1.2.1 The terminal voltage of the battery

1.2.2 The current through each resistor

(2 × 3) (6)

1.3 Define *temperature coefficient of resistance at 0 °C.* (3)

1.4 A conductor of effective length of 600 mm moves with a velocity of 15 m/s perpendicular to a magnetic field of uniform flux density of 2 T.

Determine the following:

1.4.1 The EMF induced in the conductor

1.4.2 The force acting on the conductor when it carries a current of 15 A

1.4.3 The power required to move the conductor

(3 × 1) (3)
[20]

QUESTION 2

2.1 Two capacitors each having a potential difference (PD) of 200 V and 50 V respectively are connected in series across a DC supply.

Determine the total capacitance and the capacitance across each capacitor if a charge of 800 micro coulomb is measured across the capacitors. (4)

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2.2 The field coils of a motor have a resistance of 200 ohms at 75 °C. After a run at full load, the resistance increases to 300 ohms.

Determine the temperature of the coils if the temperature coefficient of resistance is 0,004 per °C at 75 °C. (4)

2.3 A battery having an EMF of 54 volts and an internal resistance of 0,6 ohm is connected in parallel with a direct-current generator of EMF 67 volts and internal resistance of 0,5 ohm. The combination is used to supply a load having a resistance of 3,8 ohms.

Use Kirchhoff 's laws to determine the following:

2.3.1 The value and direction of the current through the battery

2.3.2 The value and direction of the current through the generator

2.3.3 The potential difference across the load (9)

2.4 Define the *ampere*. (3)
[20]

QUESTION 3

3.1 Calculate the speed of a four-pole series generator having a wave-wound armature with 315 conductors and resistance of 0, 6 ohm supplying a load of 50 kW at 1 000 V. The resistance of the field-winding brush contact resistance is 0,4 ohm. The field sets up a flux per pole of 0,1 Wb. (5)

3.2 What type of winding would be used for the following:

3.2.1 A high-voltage low-current

3.2.2 A high-current low-voltage DC machine.

(2)

3.3 The open-circuit characteristics of a shunt-excited DC machine are as follows:

Terminal voltage (V)	80	160	240	320	340	360
Field current (A)	4	8	12	20	24	30

Plot a graph and determine the open-circuit voltage if the field circuit resistance is 12 ohms. (8)

3.4 A short-shunt compound generator supplies a load current of 100 A. It has a shunt-field resistance of 20 ohms, an armature resistance of 0, 3 ohm and a field resistance of 0, 2 ohm.

Determine the armature EMF if the terminal voltage is 180 V. (5)
[20]

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QUESTION 4

4.1 A sinusoidal alternating current supply has a maximum value of 396,04 V and a periodic time of 50 milliseconds.

Determine the following:

4.1.1 The RMS value of the voltage

4.1.2 The average value of the voltage

4.1.3 The frequency

4.1.4 The instantaneous value two milliseconds after the commencement of the cycle

(4)

4.2 A 48 kVA 4 800/48 V, 50 Hz single-phase transformer has 3 000 turns on the primary winding.

Determine the following:

4.2.1 The turns ratio

4.2.2 The number of secondary turns

4.2.3 The secondary full-load current

4.2.4 The maximum value of the core flux

(8)

4.3 In a certain circuit having TWO parallel branches the instantaneous branch circuits are represented by:

$$i_1 = 15Sin(wt + \frac{\pi}{4})$$

$$i_2 = 45Sin(wt - \frac{\pi}{4})$$

4.3.1 Determine the total current and write it in this form:

$$i = I_{max}Sin(wt + \theta)$$ (5)

4.3.2 Represent these currents by drawing a phasor diagram. (3)

[20]

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QUESTION 5

5.1 At what speed must a six-pole alternator be driven to produce an EMF having a frequency of 60 Hz? (2)

5.2 What motor is superior in efficiency and the most extensively used of all types of electric motors? (2)

5.3 An impedance of 15 $\angle 45$ ohms and an impedance of 15 $\angle -45$ ohms are connected in parallel to a 150 volt, 50 Hz supply.

Determine the following:

5.3.1 The total impedance

5.3.2 The current in each branch

5.3.3 The current flowing in the circuit

5.3.4 The overall power factor and

5.3.5 Draw the phasor diagram to present the current in the circuit. (10)

5.4 A milli-ammeter with a 5 ohms coil resistance indicates a full-scale deflection when a current of 1 000 m A flows through it.

Determine the value of the resistances required to enable the instrument to be used as a …

5.4.1 10 V voltmeter (2)

5.4.2 1,5 A ammeter (2)

5.5 Why are coal-fired power stations normally built far away from the main load points? (2)

[20]

TOTAL: 100

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ELECTROTECHNICS N4

FORMULA SHEET

Any applicable formula may also be used.

1. Principles of electricity

$$E = V + Ir$$

$$V = IR$$

$$R_{se} = R_1 + R_2 + \dots R_n$$

$$R_p = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \dots \frac{1}{R_n}}$$

$$R = \rho \frac{\ell}{a}$$

$$\frac{R_1}{R_2} = \frac{1 + \alpha_o T_1}{1 + \alpha_o T_2}$$

$$R_t = R_\theta \left[1 + \alpha_\theta \left(t - \theta\right)\right]$$

$$P = VI = I^2 R = \frac{V^2}{R}$$

$$\Phi = \frac{mmf}{S} = \frac{IN}{S}$$

$$H = \frac{IN}{\ell}$$

$$F = B\ell I$$

$$E = \frac{\Delta\Phi}{\Delta t} . N$$

$$E = B\ell v$$

$$E = \frac{L\Delta I}{\Delta t}$$

$$L = \frac{\Delta\Phi}{\Delta I} . N$$

$$Q = VC$$

$$Q_{se} = Q_t = Q_1 = Q_2 \dots = Q_n$$

$$C_{se} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \dots \frac{1}{C_n}}$$

$$Q_p = Q_1 + Q_2 + \dots Q_n$$

$$C_p = C_1 + C_2 + \dots C_n$$

2. Direct-current machines

$$E = \frac{2Z}{c} . \frac{Np}{60} . \Phi$$

$$c = 2a$$

$$E_{gen} = V + I_a R_a$$

$$E_{mot} = V - I_a R_a$$

$$R_{start} = \frac{(V - E)}{I_a} - R_a$$

3. Alternating-current machines

$$E_m = 2\pi BANn$$

$$e = E_m \sin\left(2\pi f . t \times 57{,}3\right)^\circ$$

$$E_{ave} = 0{,}637\ E_m$$

$$E_{rms} = 0{,}707\ E_m$$

$$T = \frac{1}{f}$$

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FORMULA SHEET (Continued)

$$f = \frac{Np}{60}$$

$$\omega = 2\pi f$$

$$Z_L = R + j\omega L$$

$$Z_c = R - j\frac{1}{\omega C}$$

$$pf = \cos\phi = \frac{R}{Z}$$

$$S = VI$$

$$P = V.I\cos\phi = I^2R$$

$$Q = V.I\sin\phi$$

4. Transformers

$$E = 4{,}44\ f\ \Phi_m\ N$$

$$k_t = \frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{I_2}{I_1}$$

5. Measuring instruments

$$R_{SH} = \frac{i_m\ R_m}{I_{sh}}$$

$$R_{se} = \frac{V}{i_m} - R_m$$

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MARKING GUIDELINE

NATIONAL CERTIFICATE

ELECTROTECHNICS N4

8 NOVEMBER 2013

This marking guideline consists of 8 pages.

QUESTION 1

1.1
$$A_a = \frac{\pi d^2 a}{4} = \frac{\pi(25\times10^{-3})^2}{4} = 4{,}909\times10^{-4} m^2 \quad \surd\surd$$
$$but\ I_a = I_T - I_C = 150 - 50 = 100\ A \quad \surd$$
$$R_a = \frac{P_a x L_a}{A_a} = \frac{0{,}027\times10^{-6}\ x500}{4{,}909\times10^{-3}} = 0{,}275\ \Omega\ \surd$$

1.1.1
$$V_a = I_a R_a = 100\times0{,}0275 = 2{,}75\ V \quad \surd$$
$$R_c = \frac{v_c}{I_c} = \frac{2{,}75}{50}\ 0{,}055\ \Omega\ \surd$$

1.1.2
$$d = \sqrt{\frac{4PcLc}{\Pi\ R_C}}$$
$$= \sqrt{\frac{4\times0{,}017\times10^{-6}\times500}{\Pi\ (0{,}055)}} \quad \surd\surd$$
$$= 14{,}027\ mm$$

(2 × 4) (8)

1.2
$$R_T = R_{se} + \frac{1}{\frac{1}{R_1}+\frac{1}{R_2}} \qquad I = \frac{E}{R_T + r} \qquad (1.2.1)\ V = IR_T$$
$$= 3 + \frac{1}{\frac{1}{6}+\frac{1}{30}} \qquad = \frac{27}{8+1} \qquad = 3\times8$$
$$= 3 + \frac{1}{0{,}2} \qquad = \frac{27}{9} \qquad = \underline{24\ V}\ \surd$$
$$= 3 + 5 \qquad = \underline{3\ A}\ \surd$$
$$= 8\ \Omega\ \surd$$
$$I_P = 3\ A$$

1.2.1 but $V_P = I\ R_P$ = 3 x 5 = 15 V√

1.2.2 Thus:
$$I_1 = \frac{V}{R_1} = \frac{15}{6} = 2{,}5\ A \quad \surd\surd$$
$$I_2 = \frac{V}{R_2} = \frac{15}{30} = 0{,}5\ A$$

(2 × 3) (6)

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1.3 The temperature coefficient of resistance of a material at 0 °C is the increase in resistance of a sample having a resistance of one ohm at 0 °C, when its temperature is raised by 1°C (or 1 K) √√√ (3)

1.4 1.4.1 EMK = BLV = 2 x 0,6 x 15 = 18 V√

1.4.2 F = BLI = 2 x 0,6 x 15 = 18 N√

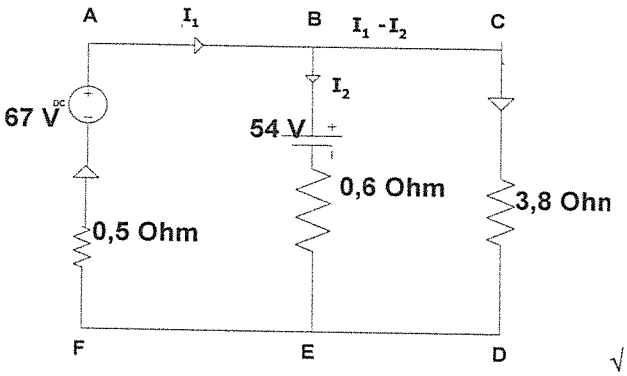
1.4.3 P = VI = 18 x 15 = 270 W√ (3 × 1) (3)
[20]

QUESTION 2

2.1
$$C_S = \frac{1}{\frac{1}{4}+\frac{1}{16}} = \frac{3{,}2\mu F}{} \surd\surd$$
$$Q_T = Q_1 = Q_2 = V_1C_1 = V_2C_2$$
$$C_1 = Q_1 / V_1 = 800/50 = 16\mu F \surd$$
$$C_2 = Q_2 / V_2 = 800/200 = 4\ \mu F \surd$$
(4)

2.2
$$R_t = R_{75}[1 + a_{75}(t-0)]$$
$$300 = 200[1 + 0{,}004\ (t - 75^\circ)]$$
$$(t-75) = \frac{(\frac{300}{200}-1)}{0{,}004} \qquad \surd\surd\surd\surd$$
$$t = (\frac{1{,}5-1}{0{,}004}) + 75$$
$$= 125 + 75$$
$$t = 200\ ^\circ C$$
(4)

2.3



√

$$(E_1 - E_2) - (I_1R_1 + I_2R_2R_2) = 0$$
$$(67-54) - (I_1 0{,}5 + I_2 0{,}6) = 0 \surd$$
$$13 - I_1 0{,}5 - I_2 0{,}6 = 0$$

$$(E_1 - (I_1R_1 + R_3(I_1 - I_2) = 0$$
$$67 - [0{,}5I_1 + 3{,}8\,(I_1 - I_2)] = 0 \quad \surd$$
$$67 - 4{,}3\,I_1 + 3{,}8\,I_2 = 0$$

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Eq (1) x 3.8/0,6 $82{,}333 - 3{,}167\ I_1 - 3{,}8\ I_2 = 0$ ……√
Eq.(2) + (3) = $149{,}3333 - 7{,}4667\ I_1 = 0$ √
Thus $I_1 = 149{,}333/7{,}467 = 20$ A
Substitude $I_1 = 20$ A into Eq. (1)
$13 - 0{,}5(20) = 0{,}6\ I_2$
$I_2 = 13 - 10/0{,}6 = 3/0{,}6 =$ 5 A
$I_1 - I_2 =$ 15 A √

2.3.1 $I_2 =$ 5 A from pos. to neg.√

2.3.2 $I_1 = 20$ A from pos. to neg.√

2.3.3 PD = IR = 15 x 3,8 = 57 V√ (3 × 3) (9)

2.4 The ampere is defined as the current which if maintained in two straight parallel conductors of infinite length of negligible cross-sectional area, and placed 1 metre apart in a vacuum, would produce between the conductors a force of 2×10^{-7} newton per metre of length.√√√ (3)
[20]

QUESTION 3

3.1 Flux =0,1 Wb P = 2√ C = 2 √ Z = 315

$I_a = I_L = P/V = 50 \times 10^3 / 1000 = 50\ A$

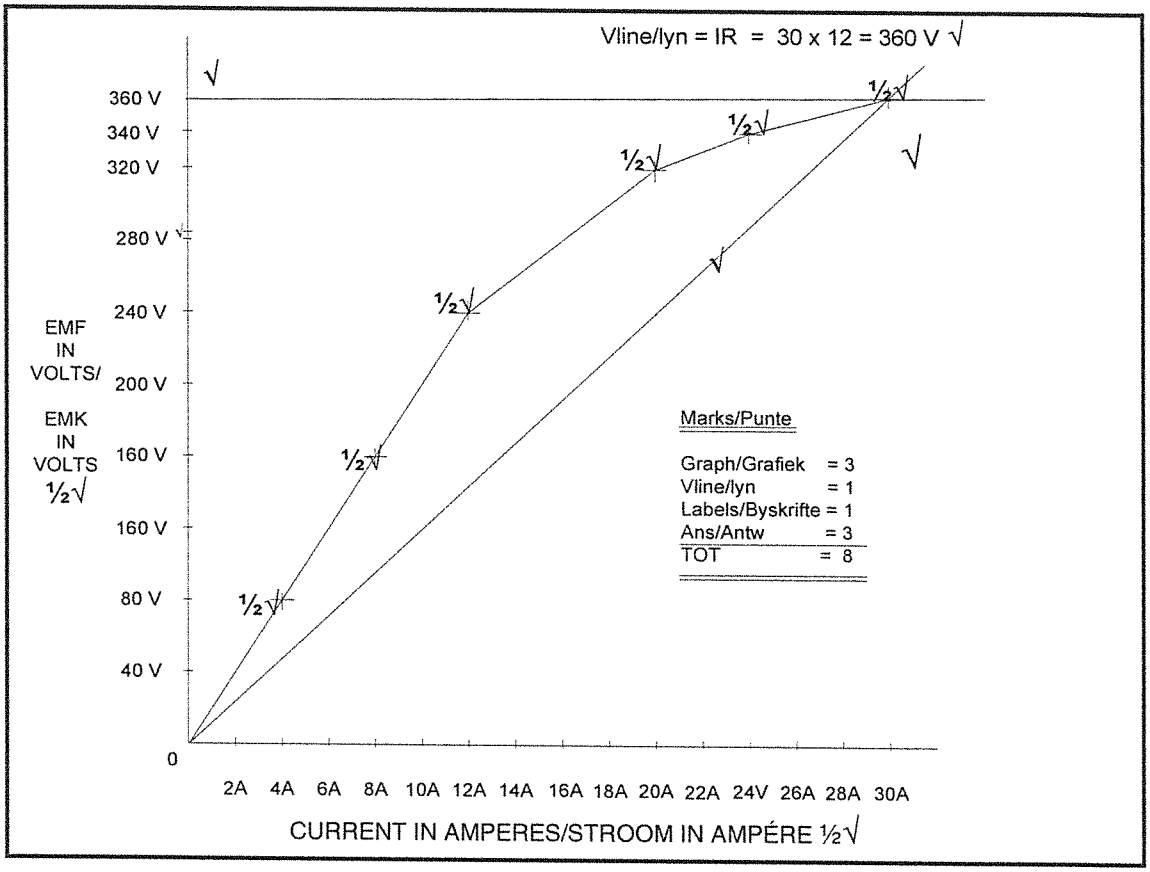
$E = V + I_a (R_a + R_{se})$
$= 1000 + 50\ (0{,}6 + 0{,}4)$
$= 1050\ V$ √

$E = (2Z/C)(NP/60) \times \Phi_m$
$1050 = (2 \times 315/2)(N2/60) \times 0{,}1$ √
$N = 0{,}105\ N$
$= 1000\ RPM$ √ (5)

3.2 3.2.1 Wave√

3.2.2 Lap√ (2)

3.3



(8)

3.4

$$I_{SH} = \frac{V + I_L R_{SE}}{R_{SH}}$$

$$= \frac{180 + (100 \times 0{,}2)}{20} \surd\surd$$

$$= \frac{200}{20}$$

$$\underline{10\ A}$$

$$E = V + I_a R_a + I_L R_{SE}$$
$$= 180 + (110 \times 0{,}3) + 100(0{,}2)$$
$$= 180 + 33 + 20$$
$$= 233\ V$$

$$I_a = I_L + I_{SH}$$
$$= 100 + 10$$
$$= 110\ A$$

(5)
[20]

QUESTION 4

4.1 4.1.1 $E_R = 0{,}707\ E_M = 0{,}707 \times 396{,}04 = 280\ \text{V}\surd$

4.1.2 $E_{AVE} = 0{,}637\ E_M = 0{,}637 \times 396{,}04 = 252{,}28\ \text{V}\surd$

4.1.3 $f = 1/T = 1/50 \times 10^{-3} = 20\ \text{Hz}\surd$

4.1.4 $e = E_M \sin 2\Pi ft \times 180/\Pi$
$= 396{,}04 \sin(2\Pi 20 \times 0{,}02 \times 180/\Pi)\surd$
$= 396{,}04 \sin 14.4$
$= 98.49\ \text{V}\surd$

(1 × 4) (4)

4.2 4.2.1 $\frac{N_1}{N_2} = 4\,800/48 = 100\ (100:1)$ √

4.2.2 $N_2 = \frac{N_1 V_2}{V_1} = \frac{3\,000 \times 48}{4\,800} = 30\ Turns$ √√

4.2.3 $I_2 = \frac{S}{V} = \frac{48\,000}{48} = 1\,000\ A$ √√

4.2.4 Core Flux = E/4,44fN = 4 800/4,44 × 50 × 3 000= 7,207 mWb√√

(2 × 4) (8)

4.3 4.3.1 $i_1 = 15\angle 45^\circ = 10{,}607 + j10{,}607$ √√

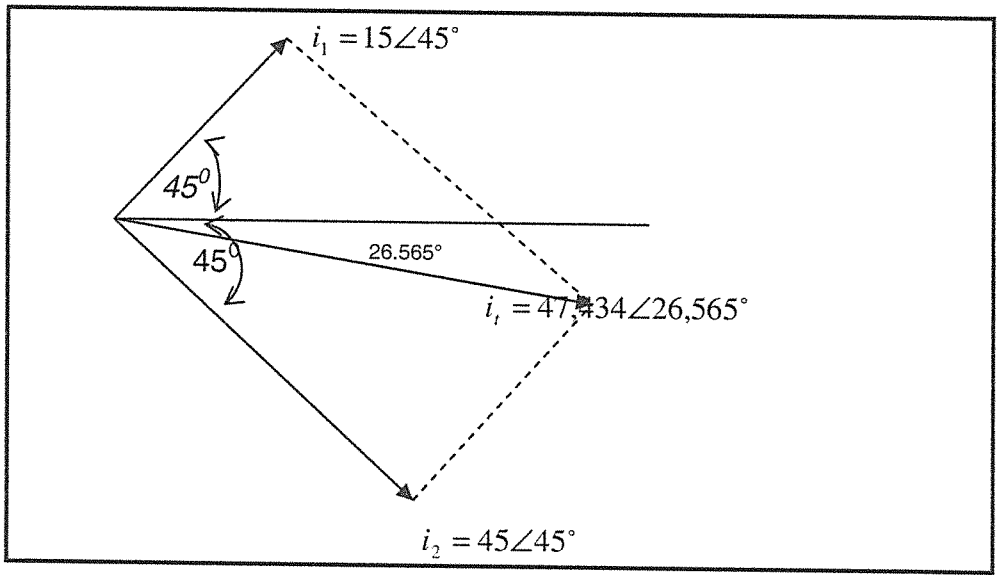
$i_2 = 45\angle -45^\circ = 31{,}82 - j31{,}82$

Total I = 42,426 - j 21,213 = 47,434 ∠ -26,565° √√

$I_T = 47{,}434\ Sin\ (wt - 26{,}565^\circ)$ √

(5)

4.3.2



(3)
[20]

QUESTION 5

5.1 $f = \frac{PN}{60}$

$N = \frac{f \times 60}{P} = \frac{60 \times 60}{3} = 1\,200\ RPM$ √√

(2)

5.2 AC motors (or) Induction motors √√ (2)

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5.3 $Z_1 = 15\angle 45 = 10{,}607 + j10{,}607$

$Z_2 = 15\angle -45 = 10{,}607 - j10{,}607$

$Z_1 + Z_2 = 21{,}213 + j0$ √

5.3.1 $$Z_T = \frac{Z_1 Z_2}{Z_1 + Z_2} = \frac{225\angle 0^\circ}{21{,}213\angle 0^\circ} = 10{,}607\angle 0^\circ = 10{,}607\ \Omega\ \surd\surd$$ (2)

5.3.2 $$I_1 = \frac{V}{Z_1} = \frac{150\angle 0^\circ}{15\angle 45^\circ} 10\angle -45^\circ = 7{,}071 - j7{,}071\ A\ \surd$$

$$I_2 = \frac{V}{Z_2} = -\frac{150\angle 0^\circ}{15\angle 45^\circ} 10\angle -45^\circ = 7{,}071 - j7{,}071\ A\ \surd$$ (2)

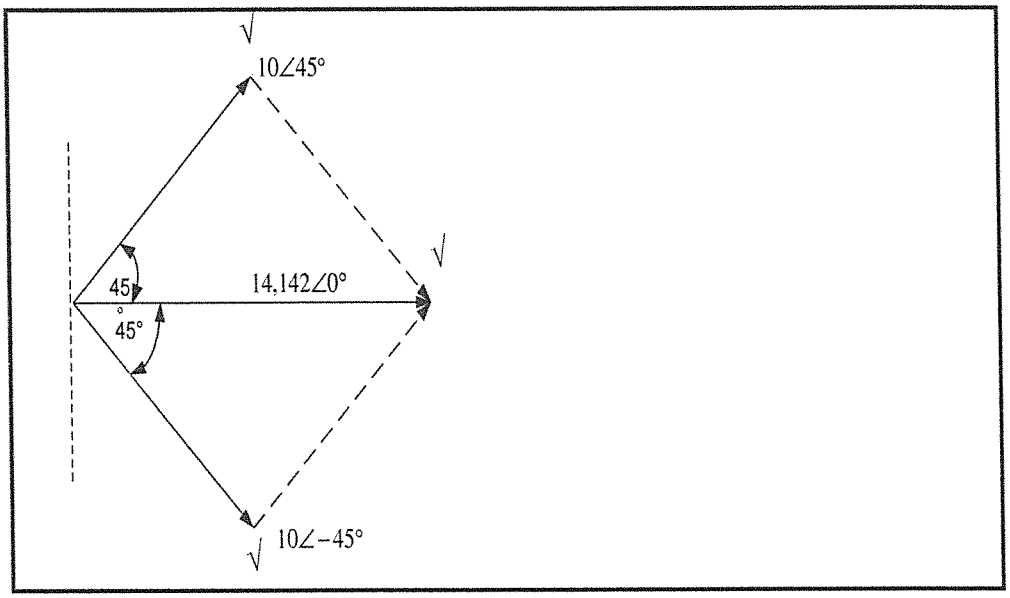
5.3.3 $I_T = I_1 + I_2 = 14{,}142 + j\,0 = 14{,}142\angle 0^\circ\ A\ \surd$ **OR**

$$I_T = \frac{V}{Z_T} = \frac{150\angle 0^\circ}{10{,}607\angle 0^\circ} = 14{,}142\angle 0^\circ = 14{,}142 + j\,0\ A = 14{,}142\ A\ \surd$$ (2)

5.3.4 p.f = Cos 0 = 1√ (2)

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5.3.5



(2)

5.4 5.4.1 $$R_{SE} = \frac{V}{I_M} - R_M = \frac{10}{1\,000 \times 10^{-3}} - 5 = 5\,\Omega \surd\surd$$

(2)

5.4.2 $$I_{SH} = I_L - I_M = 1{,}5 - 1\,000 \times 10^{-3} = 0{,}5\ A \surd$$

$$R_{SH} = \frac{I_M R_M}{I_{SH}} = \frac{1\,000 \times 10^{-3} \times 5}{0{,}5} = 10\,\Omega \surd$$

(2)

5.5 To be near the coalfields in order to reduce transport cost√√ (2)

[20]

TOTAL: 100

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