

# higher education & training

Department:  
Higher Education and Training  
**REPUBLIC OF SOUTH AFRICA**

**T440(E)(J22)T  
AUGUST EXAMINATION**

**NATIONAL CERTIFICATE**

**ELECTRICAL TRADE THEORY N2**

**(11041872)**

**22 July 2014 (Y-Paper)  
13:00–15:00**

**This question paper consists of 6 pages and 1 formula sheet.**

**DEPARTMENT OF HIGHER EDUCATION AND TRAINING**  
**REPUBLIC OF SOUTH AFRICA**  
**NATIONAL CERTIFICATE**  
**ELECTRICAL TRADE THEORY N2**  
**TIME: 2 HOURS**  
**MARKS: 100**

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**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. Where applicable, answers must be in accordance with the SABS (SANS) Code of Practice SANS 10142-1:2003 for the Wiring of Premises.
  5. Sketches must be neat, labelled and large enough to show the required detail.
  6. Formulae used in Electrical Trade Theory N2 can be found at the end of the question paper.
  7. Answers must be given to two decimal places.
  8. Write neatly and legibly.
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**QUESTION 1: CONDUCTORS AND CABLES**

- 1.1 Cables can carry fault currents that are much higher than their rated current.  
Name TWO factors that will determine the permissible fault current. (2)
- 1.2 Give TWO disadvantages of installing high-voltage cables, by suspending them in open air. (2)
- 1.3 State a variable that must be considered when selecting a cable for the following applications;
- 1.3.1 Supplying an inductive load (1)
- 1.3.2 Connecting an outlet which is very far from the point of supply (1)
- 1.3.3 Handle an expected fault current (1)
- 1.4 Answer the following questions on inductance:
- 1.4.1 State how magnetic flux brings about inductance in a conductor.
- 1.4.2 State the difference between self-induced EMF in a coil and back EMF.
- 1.4.3 Name a load which has inductance when coupled to an AC supply.
- 1.4.4 Name a load which has no inductance when coupled to an AC supply. (4 x 1) (4)
- [11]

**QUESTION 2: SWITCHGEAR, CONTACTORS AND RELAYS**

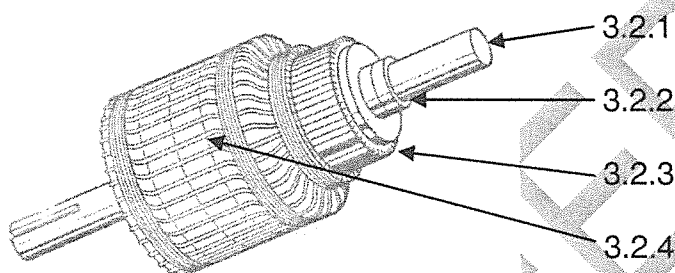
- 2.1 Explain the purpose of a relay. (2)
- 2.2 For the efficient distribution of power from power stations to consumers, electrical energy from a 3-phase 11 kV alternator, is transformed to 132 kV for long-distance transmission. At the substation it is transformed back to 11 kV, and then to a 3-phase 380 V 4-wire and to single-phase 220 V 2-wire systems. Show by means of a sketch how this is done in practice. Assume that there are consumers that need a 3-phase supply while others require single-phase supply. (6)
- 2.3 Overhead conductors are not covered with insulating material. State the two main purposes of the insulators used in this type of electrical distribution systems. (2)
- 2.4 Name TWO methods to minimize damage caused by arcing in circuit breakers. (2)
- [12]

**QUESTION 3: DC MOTORS AND STARTERS**

3.1 Name TWO components that need regular replacement in DC motors. (2)

3.2 Write 3.2.1 to 3.2.4 down in your ANSWER BOOK and correctly name all the components identified by the arrows, selecting only FOUR of the following names:

- stator windings
- armature windings,
- slip rings,
- commutator
- shaft
- spacers
- end plates



(4)

3.3 Explain the need for a motor starter. (2)

3.4 Explain what happens to the speed of a series motor as the load decreases. (2)

3.5 Name TWO methods of reversing the direction of rotation of DC motors. (2)

**[12]****QUESTION 4: AC MOTORS AND STARTERS**

4.1 For a single-phase capacitor-start, capacitor-run motor in which the capacitor values are not the same:

4.1.1 Draw a neat, fully labelled circuit diagram of the above. (4)

4.1.2 State one application of this type of motor. (1)

4.1.3 State why single phase motors are not all similar to this type of motor. (1)

4.2 The overcurrent protection devices used for motors must meet certain requirements. Discuss these requirements under the following headings:

4.2.1 The tripping value (2)

4.2.2 The time delay (2)

4.2.3 Multiphase motors (1)

4.2.4 Automatically controlled motors (1)

4.3 Give a short description of how a squirrel-cage rotor is constructed. (3)

[15]

### QUESTION 5: EARTHING

5.1 State which TWO parts of the earthing system should be connected to the consumer's earth terminal. (2)

5.2 The cable sheath is being used as the earth continuity conductor. The cable is to be joined. Explain how earth continuity is maintained if the joint is made inside a metal joint box. (2)

5.3 State what must be done with the earth conductor of a three-core cable that is connected to electrical appliances that have floating earths. (1)

5.4 Explain how the following items in an outdoor substation is earthed.

5.4.1 The transformer windings

5.4.2 The metal enclosure of the transformer

5.4.3 The lightning rods that are mounted on the highest points above the substation

(3 x 2) (6)

[11]

### QUESTION 6: PROTECTION

6.1 Answer the following questions on phase-imbalance protection:

6.1.1 State the purpose of phase-imbalance protection (1)

6.1.2 State what equipment requires phase-imbalance protection (1)

6.1.3 Explain how three-phase overload relays protect circuits against single phasing. (2)

- 6.2 State on which conductor in a circuit a fuse should be installed. (1)
- 6.3 Name the application and purpose of a valve arrestor. (2)
- 6.4 List the FOUR main components of the bimetal type overload relay. (4)

**[11]****QUESTION 7: MEASURING INSTRUMENTS**

- 7.1 Explain how the watt-hour meter is able to give a reading which is proportional to the energy consumed. (3)
- 7.2 Draw a neat, fully labelled circuit diagram to show how a wattmeter is connected to a single-phase system. Assume that the wattmeter is rated for the high voltage and current present in the system. Label the coils of the meter. (3)

**[6]****QUESTION 8: TRANSFORMERS**

A three-phase transformer has a delta-connected primary and a star-connected secondary. The transformer is connected to a 132 kV supply. The secondary-phase voltage is found to be 11 kV. Calculate the following:

- 8.1 The primary-phase voltage (1)
- 8.2 The secondary-line voltage (2)
- 8.3 The secondary-phase current when it draws its full load current of 120 A from the supply (6)
- 8.4 The transformer rating in MVA (3)

**[12]****QUESTION 9: ELECTRONICS**

- 9.1 Explain the operation of a diode. (2)
- 9.2 Explain the construction of a transistor. (2)
- 9.3 Explain how a SCR is triggered. (2)
- 9.4 Draw a neat, fully labelled circuit diagram to show how full-wave rectification can be obtained using two diodes and a centre-tap transformer. (4)

**[10]****TOTAL: 100**

**FORMULA SHEET**

$$I_T = \frac{V}{Z}$$

$$I_{ACTIVE/AKTIEWE} = I_T \cos \theta$$

$$I_{REACTIVE/REAKTIEWE} = I_T \sin \theta$$

$$X_L = 2\pi fL$$

$$X_C = \frac{1}{2\pi fC}$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$\theta = \cos^{-1} \left[ \frac{R}{Z} \right]$$

$$V_R = I_T R$$

$$V_{X_L} = I_T X_L$$

$$V_{X_C} = I_T X_C$$

$$V = \sqrt{V_R^2 + (V_{X_L} - V_{X_C})^2}$$

$$P = I^2 R$$

$$P = \sqrt{3} V_L I_L \cos \theta$$

$$S = VI$$

$$S = \sqrt{3} V_L I_L$$

DELTA

$$V_L = V_{PH/F}$$

$$I_L = \sqrt{3} I_{PH/F}$$

STAR/STER

$$V_L = \sqrt{3} V_{PH/F}$$

$$I_L = I_{PH/F}$$

CABLES/KABELS

$$I_{fc} = \frac{CIF \times A}{\sqrt{E}}$$

$$\frac{V_p}{V_s} = \frac{N_p}{N_s} = \frac{I_s}{I_p}$$

$$\omega = 2\pi f$$

$$I = \frac{V - E}{R_a}$$

Series motor/Seriemotor

$$I_L = I_{se} = I_a$$

Long shunt/Langsjunt

$$I_{se} = I_a$$

$$I_L = I_a + I_{sh/sj}$$

Short shunt / Kortsjunt

$$I_L = I_{se}$$

$$I_L = I_a + I_{sh/sj}$$

$$N = \frac{f \cdot 60}{p}$$

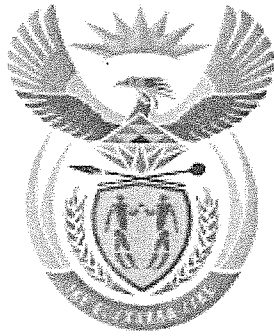
$$s = \frac{n - n_r}{n}$$

Series Resistors/Serieresistors

$$R_T = R_1 + R_2 + \dots + R_n$$

Parallel Resistors/ Parallelresistors

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



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## **MARKING GUIDELINE**

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**ELECTRICAL TRADE THEORY N2**  
**22 JULY 2014**

**This marking guideline consists of 8 pages.**



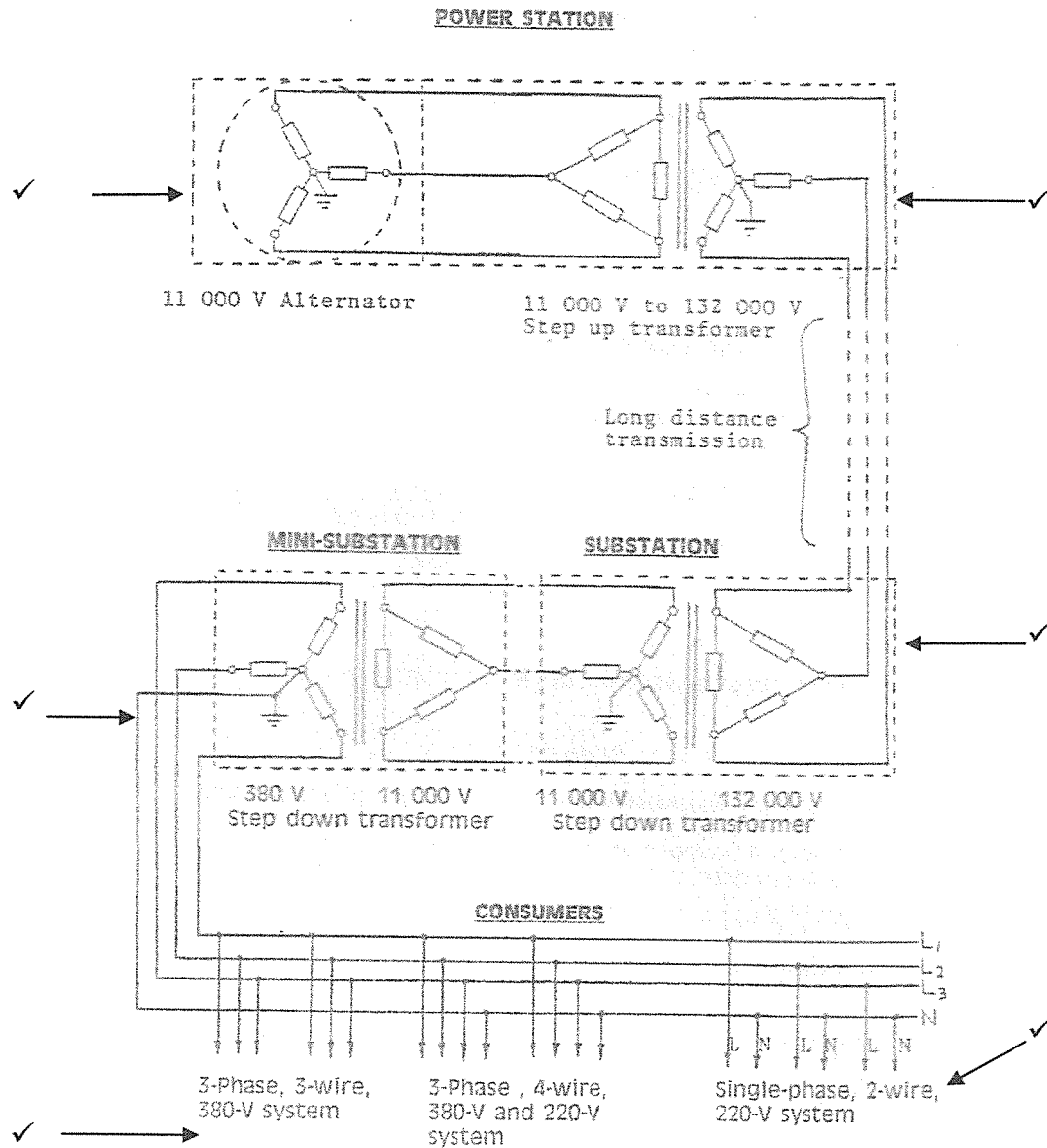
**QUESTION 1**

- 1.1
- The conductor and insulation factor✓
  - The conductor cross sectional area✓
  - The time duration of the fault current
- (Any 2 x 1) (2)
- 1.2
- Exposed to mechanical damage✓
  - Exposed to the elements✓
  - Exposed to sabotage & vandalism
  - Exposed to theft
  - Unsightly
- (Any 2 x 1) (2)
- 1.3
- 1.3.1 The total current the cable has to carry (not the true power, but the kVA). ✓ (1)
- 1.3.2 Make sure the voltage drop across the cable does not exceed 5% of the supply voltage. ✓ (1)
- 1.3.3 The time✓that the cable has to carry the expected fault current without any damage. (1)
- 1.4
- 1.4.1 A change in flux around the coil / conductor induces an emf ✓
- 1.4.2 It is the same phenomenon✓
- 1.4.3 Any coil of conductive material✓ OR any conductor under the influence of a changing magnetic field
- 1.4.4 A pure resistor or capacitor✓
- (4 x 1) (4)  
[11]

**QUESTION 2**

- 2.1 A relay is able to switch circuits on or off ✓ with the aid of a secondary circuit that uses less voltage and current (control circuit✓). (2)

2.2



(6)

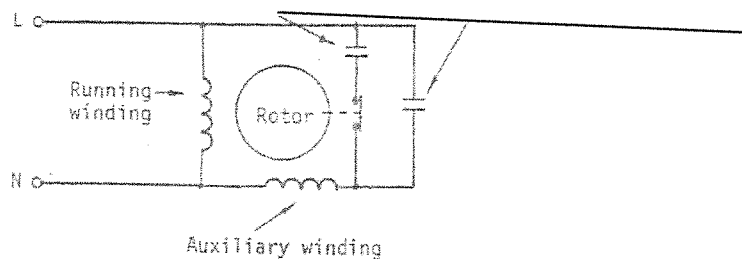
- 2.3 To tie the conductors to a support structure. ✓ To separate conductors from each other so that they do not touch. ✓ (2)
- 2.4 Arc extinguishers ✓ and silver-tungsten contact points ✓. (2)
- [12]

**QUESTION 3**

- 3.1 The brushes ✓ and the bushes ✓ (bearings). (2)
- 3.2 3.2.1 Shaft ✓.  
3.2.2 Spacers ✓.  
3.2.3 Commutator ✓.  
3.2.4 Armature windings ✓. (4 x 1) (4)
- 3.3 Motor starters are used to connect the motor to the supply ✓ and to protect the motor against overloading ✓. The motor starter also protects the operator against the motor restarting after power outages. (2)
- 3.4 The speed increases exponentially ✓ to dangerous levels ✓. (2)
- 3.5 Reverse either the field ✓ or the armature connections ✓. (2)
- [12]

**QUESTION 4**

4.1 4.1.1



Sketch correct (must have 2 caps) ✓✓

Any 2 labels ✓ (4)

- 4.1.2 The motor supplies a more constant torque during starting and running. ✓ (1)

(1)

## ELECTRICAL TRADE THEORY N2

- 4.1.3 The motor is too expensive and not necessary for certain applications. OR  
Higher maintenance is required because of the centrifugal switch.

- 4.2 4.2.1 The tripping value must be about 20% above ✓ the motor full load current rating. ✓ (2)
- 4.2.2 The time delay must be shortened according to the size of the overload, no time delay for short circuit, ✓ very little time delay if rotor locked. ✓ (2)
- 4.2.3 Protection prevents multiphase motors from operating if a phase has no voltage. ✓ (1)
- 4.2.4 Automatically controlled motors must be manually reset before allowing restart. ✓ (1)
- 4.3 The rotor has a shaft and the metal core is made up of steel laminations. ✓ There are conductive bars on the surface of the core. ✓ These bars are shorted together by conductive plates at both ends. ✓ (3)

[15]

## QUESTION 5

- 5.1 The consumer earth continuity conductors ✓ and the earth lead (protective conductor) providing continuity to the suppliers earth/earth electrode. ✓ (2)
- 5.2 The cable sheath is tightened to the metal joint box by means of a metal gland. ✓ The metal gland puts enough pressure on the wire armouring to ensure continuity. ✓ The joint box's paint must be removed under the gland to ensure continuity. ✓ (The answer must show how earth continuity is achieved) (2)
- 5.3 Electrical appliances that have floating earths need not be earthed. Rather use a two core cable or tie off earth conductor to prevent it from touching live conducting parts. ✓ (1)
- 5.4 5.4.1 The transformer windings can only be earthed at the star point ✓ of the star winding. ✓
- 5.4.2 The metal enclosure of the transformer must be connected with an earth continuity conductor ✓ to the earth terminal or directly to the earth electrode/ mat. ✓
- 5.4.3 The lightning rods that are mounted on the highest points above the substation must be connected with an earth continuity conductor ✓ to the earth terminal or directly to the earth electrode/ mat. ✓ (answers must ensure earth continuity to earth)

(3 x 2)

(6)

[11]

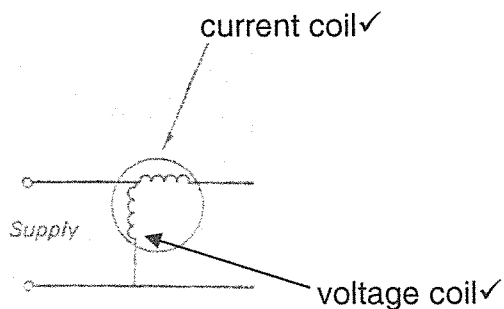
**QUESTION 6**

- 6.1 6.1.1 The purpose of phase imbalance protection is to disconnect all phases✓ when the currents differ by a specified amount. ✓ (1)
- 6.1.2 Motors and supply lines require phase imbalance protection. ✓ (1)
- 6.1.3 Phase overload relays protect circuits against single phasing because they trip all ✓phases when current in one phase is excessive. ✓ (2)
- 6.2 Fuses should be installed in the live supply wire that feeds the circuit. ✓ (1)
- 6.3 Valve arrestors are found in high voltage distribution networks✓ as protection✓ against voltage-surges caused by lightning strikes. (2)
- 6.4 The four main components that make up the bi-metal type relay are a heating element, ✓a bi-metal strip✓, snap action contacts✓ and a reset device✓. (4)
- [11]**

**QUESTION 7**

- 7.1 The product of power and time✓ (energy) determined when a disc connected to a metering unit is rotated through a magnetic field ✓ The speed of rotation is proportional to the power consumed✓. The number of rotations in a certain time represents the energy consumed. (3)

7.2



Award ONE mark for either supply OR load ✓

(3)  
**[6]**

**QUESTION 8**

- 8.1 The primary phase voltage = The primary line voltage  
 $V_{p\text{ ph}} = 132 \text{ kV} \checkmark$  (must have units) (1)

- 8.2 The secondary line voltage =  $\sqrt{3}$  x The secondary phase voltage  
 $V_{sL} = \sqrt{3} \times 11 \checkmark$   
 $= 19,05 \text{ kV} \checkmark$  (2)

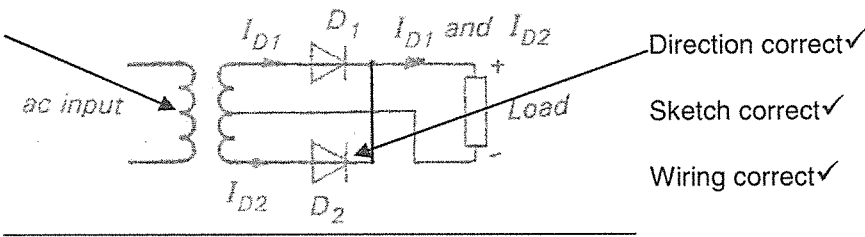
- 8.3 The secondary phase current = The primary phase current x turns ratio  
 turns ratio =  $V_{p\text{ ph}}/V_{s\text{ ph}} \checkmark$   
 $= 132/11$   
 $= 12:1 \checkmark$

$$\begin{aligned} \text{The primary phase current} &= I_{pL}/\sqrt{3} \checkmark \\ I_{p\text{ ph}} &= 120/\sqrt{3} \checkmark \\ &= 69,28 \text{ A} \checkmark \\ \text{Thus } I_{s\text{ ph}} &= 69,28 \times 12 \checkmark \\ &= 831,38 \text{ A} \checkmark \end{aligned} \quad (6)$$

- 8.4 The transformer rating in MVA =  $\sqrt{3} \times V_{pL} \times I_{pL} \checkmark$   
 $= \sqrt{3} \cdot 132\,000 \cdot 120 \cdot 10^{-6} \checkmark$   
 $= 27,44 \text{ MVA} \checkmark$  (3)  
**[12]**

**QUESTION 9**

- 9.1 A diode conducts when the anode is more positive than the cathode (The diode will have a low resistance when forward biased)  $\checkmark$ .  
 High resistance when reverse biased  $\checkmark$ . (2)
- 9.2 A transistor is made up of three layers of P- and N-type semiconductor material  $\checkmark$ .  
 Connecting leads are connected to the 3 layers to connect to external circuitry.  $\checkmark$   
 The leads are identified as a Collector, Base and Emitter. (2)
- 9.3 A pulse on the gate will switch it on  $\checkmark$ , provided the anode is more positive than the cathode  $\checkmark$ . (2)

- 9.4 Transformer correct  $\checkmark$
- 
- Direction correct  $\checkmark$   
 Sketch correct  $\checkmark$   
 Wiring correct  $\checkmark$  (4)  
**[10]**

**TOTAL: 100**