

# higher education & training

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

T460(E)(A17)T  
APRIL EXAMINATION

**NATIONAL CERTIFICATE**

**ELECTRICAL TRADE THEORY N2**

(11041872)

**17 April 2015 (Y-Paper)**  
**13:00–16:00**

**This question paper consists of 7 pages and 1 formula sheet.**

**DEPARTMENT OF HIGHER EDUCATION AND TRAINING**  
**REPUBLIC OF SOUTH AFRICA**  
**NATIONAL CERTIFICATE**  
**ELECTRICAL TRADE THEORY N2**  
**TIME: 3 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. Answers must be given to two decimal places.
  7. Write neatly and legibly.
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**QUESTION 1: CONDUCTORS AND CABLES**

- 1.1 List three advantages of installing cables in ducts. (3)
- 1.2 State whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (1.2.1—1.2.3) in the ANSWER BOOK.
- 1.2.1 It is cheaper to install cables underground because the cables need not be covered with insulation.
- 1.2.2 It is allowable for cables to work above their maximum current rating for long periods of time.
- 1.2.3 The best way to prevent cables from being hit by lightning is to bury them. (3 x 1) (3)
- 1.3 When the cable size has to be determined to supply a given amount of power, you need to know if the loads are highly inductive. Use a formula to assist you in explaining why this is so. (3)
- 1.4 The supply point to a block of flats is 230 V. What is the minimum permissible voltage at any outlet point? (2)
- [11]

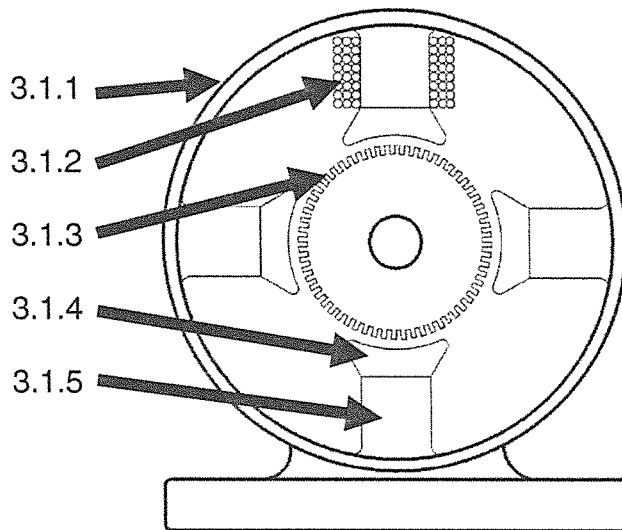
**QUESTION 2: SWITCHGEAR, CONTACTORS AND RELAYS**

- 2.1 State which visual indication informs you that an MCB (miniature) has tripped. (1)
- 2.2 Name the function/purpose of a circuit breaker. (1)
- 2.3 Explain why MCBs (miniature circuit breakers) are factory sealed. (2)
- 2.4 List TWO electric devices that use a relatively small current to switch on a circuit that has a relatively larger current. (2)
- 2.5 State whether the following joints are better suited for low voltage or high voltage applications:
- 2.5.1 Cold shrink joint
- 2.5.2 Insulated screw connectors inside a joint box (2 x 1) (2)
- 2.6 Explain the principle of operation of the thermal magnetic-type circuit breaker. (4)
- [12]

### QUESTION 3: DC MOTORS AND STARTERS

- 3.1 Label the components of the following sketch by choosing a word/term from the list below. Write only the word/term next to the question number (3.1.1—3.1.5) in the ANSWER BOOK.

stator windings; armature windings; armature conductors; slip rings; commutator; slots; pole shoe; yoke; pole core; field winding



- 3.2 Indicate how the field coil in a shunt motor is internally connected with the armature windings and externally with the supply. (5)
- 3.3 Compare the thickness and length of field-coil windings in a shunt- and series motor. (1)
- 3.4 Explain what happens to the speed of a shunt motor as the load is increased. (2)
- 3.5 State the need for starters for large DC motors. (1)
- 3.6 Shunt or series motors may be coupled directly (permanent) to their loads, or by means of a clutch system. Explain which coupling system you would use for: (1)
- 3.6.1 A shunt motor
- 3.6.2 A series motor

(2 x 1) (2)  
[12]

**QUESTION 4: AC MOTORS AND STARTERS**

- 4.1 Explain the purpose of the following components found in alternating current motors:
- 4.1.1 The stator
  - 4.1.2 Slip rings
  - 4.1.3 Terminal box
- (3 x 1) (3)
- 4.2 Answer the following questions about induction motors:
- 4.2.1 State how energy is transferred from the stator to the rotor.
  - 4.2.2 State how the resultant magnetic field rotates around the stator frame in three-phase induction motors.
  - 4.2.3 State what determines the speed of rotation in a motor.
- (3 x 1) (3)
- 4.3 Explain what is wrong with the following statements:
- 4.3.1 The speed of rotation of an induction motor is called synchronous speed.
  - 4.3.2 To start a three-phase induction motor you can connect the motor to any AC Supply.
  - 4.3.3 Single-phase induction motors have wound rotors that produce opposing magnetic fields.
- (3 x 2) (6)
- 4.4 Draw a labelled circuit diagram of a single-phase induction motor that makes use of the same auxiliary winding and capacitor during both starting and running.
- (3)  
[15]

**QUESTION 5: EARTHING**

- 5.1 Explain why earthing is important. (3)
- 5.2 The metal frame of a stove has an earth terminal. Explain the 'earthing chain' that exists to eventually connect the stove to the earth electrode outside the house. (3)
- 5.3 Define *system earthing*. (2)
- 5.4 State where and for what purpose earth mats are used. (2)
- 5.5 List two typical earth-continuity conductors that the Code of Practice allows when installing cables. (2)
- [12]

**QUESTION 6: PROTECTION**

- 6.1 Describe the construction of a bimetal-type overload relay. (3)
- 6.2 Explain the operation of a bimetal-type overload relay during overload conditions. (3)
- 6.3 List TWO features/properties of an HRC (High Rupturing Capacity) fuse. (2)
- 6.4 Explain how the earth leakage relay protect you if you hold the bare neutral wire and then touch the bare live wire. (2)
- [10]

**QUESTION 7: MEASURING INSTRUMENTS**

- 7.1 Measuring instruments are important for circuit diagnostics and recording. State the name of the instrument you would use for determining the following:
- 7.1.1 The amount of electric power consumed in a month
- 7.1.2 The phase shift between the voltage and current
- 7.1.3 The instantaneous electric power consumed (3 x 1) (3)
- 7.2 Draw a circuit diagram to show how a wattmeter is connected to a single-phase system. Assume that the wattmeter is not rated for the high voltage and current present in the system. (3)
- [6]

**QUESTION 8: TRANSFORMERS**

- 8.1 An ideal transformer has 200 turns on the primary winding and 50 turns on the secondary one. If the primary winding is connected to a 110 V supply, calculate the transformer's output voltage. (3)
- 8.2 Calculate the maximum current a transformer can deliver without being damaged if the following information is known.  
Rating – 1 kVA  
Primary Supply Voltage – 250 V / 50 Hz (3)
- 8.3 Calculate the voltage per turn on the secondary winding of a transformer with the following information.  
 $V_2 = 110\text{V}$   
 $N_2 = 55\text{ Turns}$  (3)
- 8.4 When a transformer is connected to a load, it draws 10 A from the supply of 110 Volt at an angle of  $36.87^\circ$ . Calculate the reactive power. (3)  
[12]

**QUESTION 9: ELECTRONICS**

- 9.1 Describe how transistors are able to amplify a varying voltage/current signal. (4)
- 9.2 Draw a circuit diagram of the transistor circuit that operates like a switch. Indicate where the input, output and power supply are connected. (3)
- 9.3 Name an application that thyristors (SCR) can be used for. (1)
- 9.4 Explain the operating principle of a thyristor. (2)  
[10]

**TOTAL: 100**

# **FORMULA SHEET/FORMULEBLAD**

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

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

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

$$X_L = 2\pi fL$$

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

## Series / Serie

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

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

$$V_R = I_T R$$

$$V_{X_L} = I_T X_L$$

$$V_{X_C} = I_T X_C$$

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

$$P = I^2 R$$

$$S = VI$$

## 3-phase / 3-fase

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

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

## Delta

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

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

## Star / Ster

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

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

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

$$\omega = 2\pi f$$

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

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

The next five formulae are also true for voltage / Die volgende vyf formulas geld ook vir spanning

$$i = I_m \sin(\omega t)$$

$$I_{\text{rms/wgk}} = 0,707 I_m$$

$$I_{\text{ave/gem}} = 0,637 I_m$$

$$I_{\text{rms/wgk}} = \sqrt{\frac{i_1^2 + i_2^2 + \dots + i_n^2}{n}}$$

$$I_{\text{ave/gem}} = \frac{i_1 + i_2 + \dots + i_n}{n}$$

## Form factor/Vormfaktor

$$= \frac{\text{RMS - value / WGK - waarde}}{\text{AVE - value / GEM - waarde}}$$

## Crest factor/Kruinfaktor

$$= \frac{\text{MAX - value / MAKS - waarde}}{\text{RMS - value / WGK - waarde}}$$

## Series/Serie

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

## Parallel

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





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## **MARKING GUIDELINE**

**NATIONAL CERTIFICATE**

**APRIL EXAMINATION**

**ELECTRICAL TRADE THEORY N2**

**17 APRIL 2015**

**This marking guideline consists of 7 pages.**

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**NOTE TO EXAMINERS/MARKERS**

There is not only one answer or one method (approach) of answering the questions. This memorandum gives only one answer or one possible method (approach). Examiners/markers must analyse the student's solution to determine if the question has been answered and must not adhere strictly to this memorandum.

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**QUESTION 1: CONDUCTORS AND CABLES**

- 1.1 Easy to identify a cable, ✓ easy to trace/replace, ✓ easy to locate a fault, ✓ easy to add a cable to the same route. Not visible/unsightly. Well protected.  
(Any 3 x 1) (3)
- 1.2 1.2.1 False ✓  
1.2.2 False ✓  
1.2.3 True ✓  
(Any 3 x 1) (3)
- 1.3 Cable size needs to be able to carry the load current. ✓ From  $P = V.I.\cos\Phi$  ✓, we can see that less power is available if the load is not purely resistive. As the power factor ( $\cos\phi$ ) decreases, more current is needed for the same power. ✓  
(Any 3 x 1) (3)
- 1.4  $V_{\text{perm}} = V_{\text{supply}} - 5\% V_{\text{supply}}$  ✓  
 $= 230 \times 0,95$   
 $= 218,5 \text{ V}$  ✓  
(2)  
[11]

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

- 2.1 The switch arm is not in the fully closed position. ✓ (Statement must make sense.) (1)
- 2.2 To disconnect the supply from the circuit when the current exceeds the rated rating. ✓ (1)
- 2.3 To avoid tampering that will affect the MCB ratings. ✓ To validate the guarantee. ✓ (2)

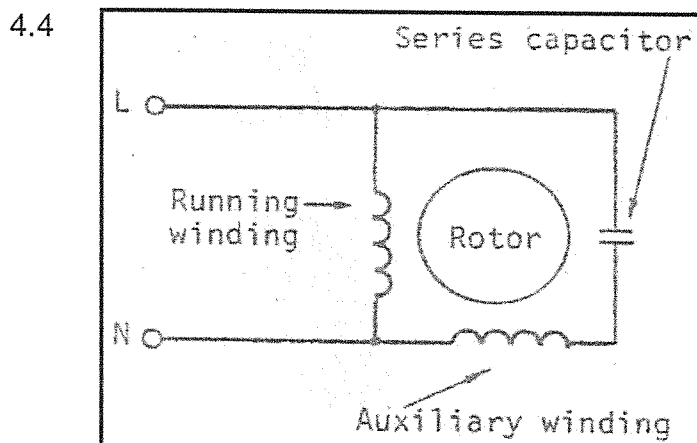
- 2.4 Relays ✓ and contactors ✓. (2)
- 2.5 2.5.1 High voltage
- 2.5.2 Low voltage (2 x 1) (2)
- 2.6 On overload ✓ the bimetal bends far enough to activate the tripping mechanism. ✓ On short circuit ✓ the magnetic field is large enough to activate the tripping mechanism. Circuit breaker has an inverse current/time delay and needs to be reset manually. ✓ (Any 4 x 1) (4)
- [12]

**QUESTION 3: DC MOTORS AND STARTERS**

- 3.1 3.1.1 Yoke. ✓
- 3.1.2 Field winding. ✓
- 3.1.3 Armature or slots or armature conductors. ✓
- 3.1.4 Pole shoe ✓
- 3.1.5 Pole core. ✓ (5 x 1) (5)
- 3.2 In parallel with the armature and across the supply. ✓ (1)
- 3.3 The shunt coil is made of a long, thin conductor ✓ whereas the series coil is made of a short, thick conductor. ✓ (2)
- 3.4 The speed remains relatively constant, ✓ dropping slightly as load increases. (1)
- 3.5 Since the starting current at full voltage is extremely high, it will damage the motor. A starter needs to limit the starting current. ✓ (1)
- 3.6 3.6.1 The load of a DC shunt motor may be coupled to it by means of a clutch so that the motor can first pick up speed after it was started. ✓
- 3.6.2 The load of a DC series motor must be coupled directly ✓ to avoid runaway (2 x 1) (2)
- [12]

**QUESTION 4: AC MOTORS AND STARTERS**

- 4.1 4.1.1 The stator is the housing (stator frame) that supports the stator core (slotted sheet steel laminations in which the windings are placed) and provides a path for the main magnetic field. ✓
- 4.1.2 Slip rings are the terminations of the rotor coils and provide electrical contact between the stationery and rotating parts. ✓
- 4.1.3 The connection box has terminals inside where the windings are connected to. ✓ The supply to the motor is connected to these terminals. (3 x 1) (3)
- 4.2 4.2.1 Entirely magnetically ✓
- 4.2.2 Because the currents through each of the 3 stator windings differ in phase by  $120^\circ$ . ✓ A sinusoidal magnetic field is set up by each winding set at  $120^\circ$  electrical apart and the 3 magnetic fields are combined to give a resultant magnetic field that rotates around the stator.
- 4.2.3 The slip as well as the supply frequency. ✓ (3 x 1) (3)
- 4.3 4.3.1 The magnetic field ✓ rotates at synchronous speed OR the rotor turns at a speed slightly less than synchronous speed.
- 4.3.2 Must be coupled to a 3-phase ✓ supply OR to decrease the starting current, first connect the stator windings of the motor in star.
- 4.3.3 They have squirrel cage rotors ✓ that develop magnetic fields. (3 x 2) (6)



Running Winding in Parallel ✓  
 Series Capacitor in Series with  
 Auxiliary Winding ✓  
 Rotor ✓

(3)  
 [15]

**QUESTION 5: EARTHING**

- 5.1 Earthing is important to protect people, animals and property from danger against leakage currents✓, static ✓ and lightning discharges✓. (3)
- 5.2 An earth conductor coming from the earth terminal in the DB ✓is connected to the stove. ✓ From the DB the earth continuity conductor ✓goes to the earth electrode. (3)
- 5.3 System earthing relates to the earthing of power systems, such as earthing the neutral. ✓ (2)
- 5.4 Buried under ground (normally in substations),✓ they provide a better earth✓ than only a single earth pen. (2)
- 5.5 A separate earth-continuity conductor that does not form part of the cable. ✓ The cable sheath or wire armouring. ✓One of the cable cores, etc. (2)
- [12]

**QUESTION 6: PROTECTION**

- 6.1 Two dissimilar metals welded together✓. One end is secured while the other is free to move✓. The trip contacts are connected to the free end✓. (3)
- 6.2 During overload conditions. – When the bimetal strip heats up the metals expand to different lengths because they have different expansion coefficients✓. During overload the current in the bimetal strip generates sufficient heat to cause the bimetal strip to bend ✓far enough to activate the tripping mechanism✓. (3)
- 6.3 It has an inverse time/current characteristic. ✓ It has an indicating device when blown. ✓ (2)
- 6.4 If you are insulated from earth the relay will not trip the supply. Should a leakage current however flow from your body to ground (earth) the earth relay will engage and trip the supply. (2)
- [10]

**QUESTION 7: MEASURING INSTRUMENTS**

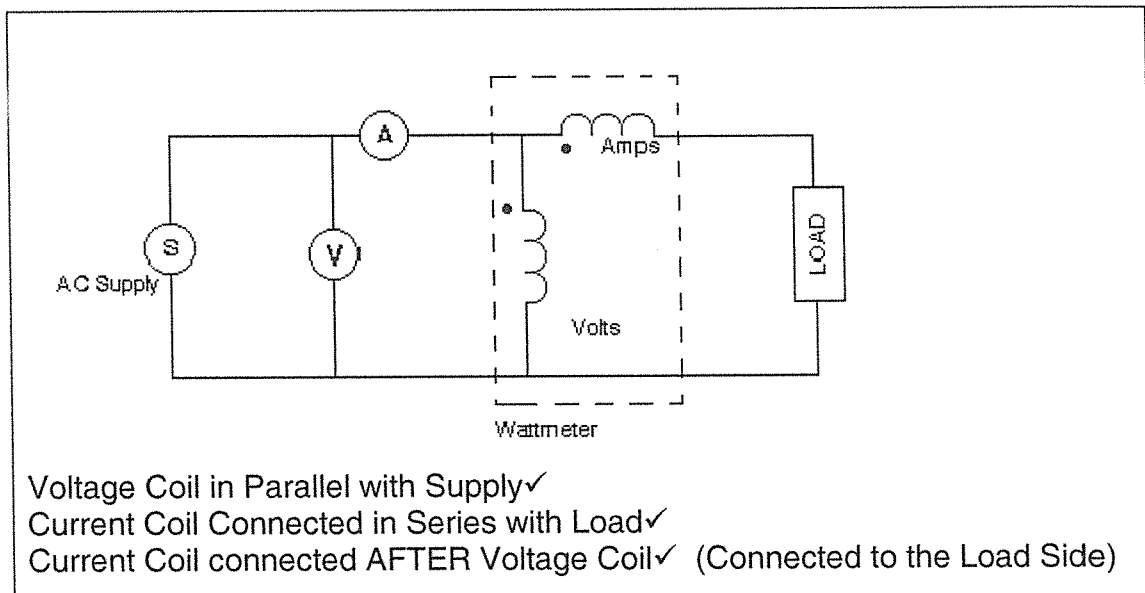
7.1 7.1.1 A kW-hr meter measures the electricity used in a month, but you have to record the reading at the beginning and end of the month. ✓

7.1.2 Power-factor meter. ✓

7.1.3 A Watt meter. ✓

(3 x 1) (3)

7.2



(3)  
[6]

**QUESTION 8: TRANSFORMERS**

8.2  $V_1/V_2 = N_1/N_2$  ✓  
 $V_2 = V_1 \times N_2 \div N_1$   
 $V_2 = 110 \times 50 \div 200$  ✓  
 $= 27,5 \text{ V}$  ✓

(3)

8.2  $P = VI$   
 $I = P/V$  ✓  
 $I = 1000 / 250$  ✓  
 $I = 4 \text{ A}$  ✓

(3)

8.3  $V/\text{turn} = V_2 / N_2$  ✓  
 $= 110 / 55$  ✓  
 $= 2 \text{ V/turn}$  ✓

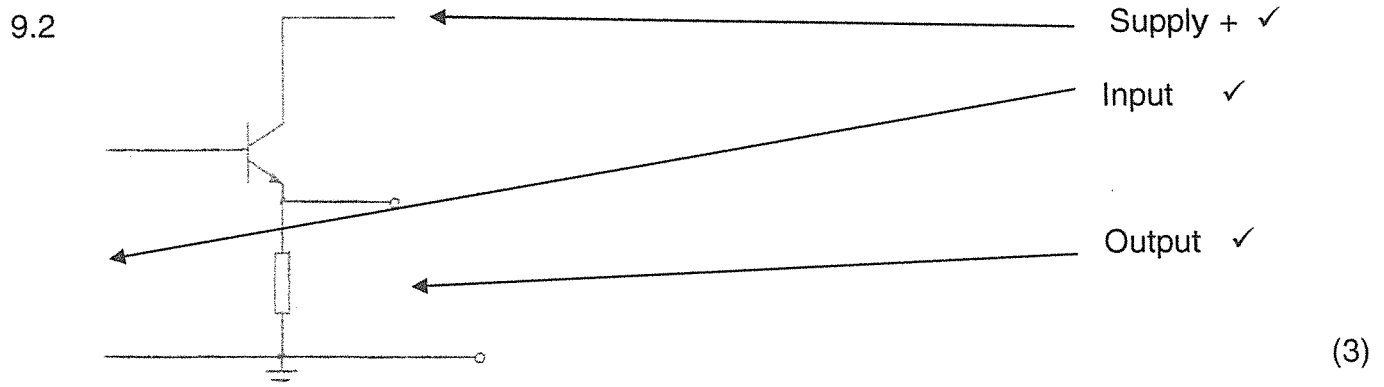
(3)

8.4  $Q = V \times I \times \sin \theta$  ✓  
 $= 110 \times 10 \times \sin(36,87^\circ)$  ✓  
 $= 660 \text{ Var OR (VAR) OR (voltamp reactive)}$  ✓

(3)  
[12]

**QUESTION 9: ELECTRONICS**

- 9.1 If a large voltage supply is connected to the collector circuit, the base can control the large collector-emitter voltage✓. A small base to emitter voltage✓ controls the amount of current that flows through the collector✓. For linear amplification the transistor must be biased midway in the active region to avoid saturation✓. (may use sketches or graphs to explain voltage amplification) (4)



- 9.3 Voltage regulation, inverters, motor control, etc. ✓ (1)

- 9.4 A thyristor blocks reverse current and only allows forward current once it receives a +pulse on the gate✓. It remains on as long as the anode is more positive than the cathode✓. (2)  
[10]

**TOTAL: 100**