higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T440(E)(M25)T

# APRIL EXAMINATION

# NATIONAL CERTIFICATE

# ELECTRICAL TRADE THEORY N2

(11041872)

**25 March 2014 (Y-Paper)**
**13:00–16:00**

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

ENGINEERING

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# 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. 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 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (1.1.1–1.1.5) in the ANSWER BOOK.

1.1.1 Since air acts as an insulator, it is cheaper to install cables in the open air because the cables need not be covered with insulation.

1.1.2 The best way to prevent cables from being hit by lightning is to run the cables in ducts.

1.1.3 If the ground is not rocky, the best way to hide unsightly cables is to bury them.

1.1.4 Once ducting exists, it is cheaper to install cables in the ducts than digging trenches and burying them.

1.1.5 Cables working at their maximum current rating need to be well-ventilated to allow for adequate heat dissipation.

(5 x 1) (5)

1.2 Determine the required current-carrying capacity of a cable that has to supply a 220 V, single-phase inductive load of 80 kW, at a power factor of 0,82. (3)

1.3 Name TWO factors that need to be considered when selecting a cable. (2)

1.4 Give a possible explanation for permissible volt drop between the supply point and any outlet point. (1)

**[11]**

## QUESTION 2: SWITCHGEAR, CONTACTORS AND RELAYS

2.1 In the electrical trade it is often required to join cables and conductors or to connect them to terminals.

Briefly describe the following:

2.1.1 The terminals

2.1.2 The insulated screw connectors

(2 x 1) (2)

2.2 Compare disconnectors, relays and contactors under the following headings and present your answer in table format:

2.2.1 Construction

2.2.2 Uses

(2 x 3) (6)

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2.3 Explain what happens within a thermal magnetic type circuit breaker under the following conditions:

2.3.1 Operation on overload

2.3.2 Operation on short circuit

(2 x 2) (4)
**[12]**

## QUESTION 3: DC MOTORS AND STARTERS

3.1 Draw the load characteristic of a shunt motor. Label both axes. (2)

3.2 What is the main advantage of a shunt motor? (1)

3.3 What is the main disadvantage of a shunt motor? (1)

3.4 Draw a circuit diagram showing how the armature and field coil of a shunt motor is connected to the supply. Indicate the supply as well as current flow in the circuit. (2)

3.5 Study the circuit diagram and graph in FIGURE 1 below and give a short explanation of the following:

3.5.1 How the starting current is limited

3.5.2 How the motor stops when the supply voltage becomes too low during normal full speed operation

3.5.3 How the supply is disconnected when the motor draws too much current

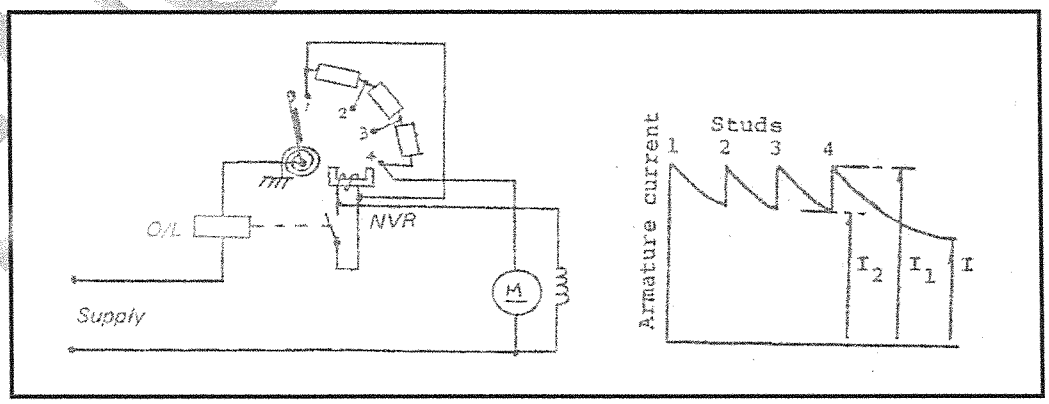


**FIGURE 1: MOTOR STARTER** (3 x 2) (6)
**[12]**

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## QUESTION 4: AC MOTORS AND STARTERS

4.1 Name TWO types of rotors found in induction motors. (2)

4.2 Rearrange the following statements so that they effectively describe the sequence of events that makes the rotor turn. Write only the question number of each statement in the correct order in the ANSWER BOOK. Do NOT copy the sentence.

4.2.1 Because the rotor windings are short-circuited, the EMF induced in these windings will cause current to flow in them.

4.2.2 The supply to the motor creates current flow in the stator coils.

4.2.3 The current in the rotor produces a magnetic field that reacts with the field from the stator coils.

4.2.4 The stator coils produce a rotating magnetic field which cuts the rotor windings.

(4 x 1) (4)

4.3 The single-phase induction motor is widely used because three-phase supply is not always available.

4.3.1 Draw a circuit diagram of a capacitor-start motor. (3)

4.3.2 Name TWO appliances that use capacitor-start motors. (2)

4.4 Name THREE types of starters that will limit the starting current of large induction motors. (3)

4.5 Name the type of motor that is used in a 300 W, 220 V AC hand drill. (1)

**[15]**

## QUESTION 5: EARTHING

5.1 Name TWO protective measures that can be used to protect people, animals and property from harmful earth fault currents. (2)

5.2 A floating earth on a portable appliance is a zero-volt connection point.

5.2.1 What should be connected to this point?

5.2.2 Name the appropriate protection method that must be used to prevent an electrical shock if the floating earth accidentally becomes live.

(2 x 1) (2)

5.3 Describe what must be done with electrical equipment that has metallic frames and/or metallic enclosures, to prevent a dangerous electric shock. (2)

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5.4 A distribution system consists of overhead lines and an outdoor substation. The outdoor substation contains switch disconnectors, surge arrestors, overload protection and star-delta transformers.

Describe how the following installations are earthed:

5.4.1 The overhead lines

5.4.2 The whole substation

5.4.3 The transformers

(3 x 2) (6)
**[12]**

## QUESTION 6: PROTECTION

6.1 Explain how a core balance earth-leakage device protects against earth faults. (4)

6.2 State how phase-imbalance protection is activated. (2)

6.3 Give ONE application of phase-imbalance protection. (1)

6.4 Explain how surge protection is activated. (2)

6.5 Give ONE example of where surge protection must be installed. (1)
**[10]**

## QUESTION 7: MEASURING INSTRUMENTS

7.1 7.1.1 State how a frequency meter is connected to a single-phase supply.

7.1.2 Name ONE other instrument that is also connected in this manner.
(2 x 1) (2)

7.2 Draw a circuit diagram to show how a wattmeter is connected to a single-phase system. (4)
**[6]**

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## QUESTION 8: TRANSFORMERS

8.1 A 100 kVA, ideal single-phase transformer's secondary voltage is 220 V. The supply to the transformer is 11 kV.

Calculate:

8.1.1 The turns ratio

8.1.2 The value of the primary current at full load

8.1.3 The maximum secondary current

(3 x 3) (9)

8.2 The primary of a 3-phase transformer is connected in star.

Calculate the phase voltage if the primary line current is 57,74 A and the supply is 380 V. (3)

**[12]**

## QUESTION 9: ELECTRONICS

9.1 Draw a neat, fully labelled circuit diagram of a full-wave bridge rectifier built with FOUR diodes. (4)

9.2 Give any THREE facts about Zener diodes. (3)

9.3 Explain how a thyristor operates as a power controlling device. (3)

**[10]**

**TOTAL: 100**

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## ELECTRICAL TRADE THEORY N2

## 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*

$$Ifc = \frac{CIF \times A}{\sqrt{t}}$$

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

$$\omega = 2\pi f$$

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

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

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

$$I_{rms} = 0{,}707\ I_m$$

$$I_{ave} = 0{,}637\ I_m$$

$$I_{rms} = \sqrt{\frac{i_1^{\ 2} + i_2^{\ 2} + \ldots i_n^{\ 2}}{n}}$$

$$I_{ave} = \frac{i_1 + i_2 + .. i_n}{n}$$

$$\text{Form factor} = \frac{\text{RMS value}}{\text{AVE value}}$$

$$\text{Crest factor} = \frac{\text{MAX value}}{\text{RMS value}}$$

SERIES

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

PARALLEL

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

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# MARKING GUIDELINE

## NATIONAL CERTIFICATE

## APRIL EXAMINATION

## ELECTRICAL TRADE THEORY N2

## 25 MARCH 2013

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

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## QUESTION 1: SWITCHGEAR, CONTACTORS AND RELAYS

1.1 The purpose of a circuit breaker is to automatically disconnect✓ an appliance or circuit from the supply in the event of an abnormal condition such as an overload.✓

OR

A circuit breaker may be used as a main or local switch disconnector✓ provided that it complies with the standards for a disconnector.

OR

A circuit breaker has a set of contacts that can be opened wide enough to stop the flow of current, ✓ OR isolate a circuit, OR trip when there is an overcurrent✓, etc. (2)

1.2 A disconnect switch must be connected on the supply side of the circuit breaker. ✓

OR

A disconnect switch should be connected between the supply and the circuit/load.✓ (1)

1.3 1.3.1 Relay✓

1.3.2 Contactor✓

1.3.3 Isolator OR disconnect switch ✓

(3)

1.4 1.4.1 In a thermal magnetic type MCB, the bi-metal strip heats up quicker✓ and bends quicker✓ when subjected to an overload current of 400%. The trip time will therefore be quicker. ✓ (3)

1.4.2 In a magnetic type MCB, the electromagnetic force✓ with which the piston will beattracted when the coil carries an overload current of 400% will be greater because of the stronger magnetic field created. This will force the oil quickly✓ through the holes and the piston can then assist in tripping the mechanism with a shorter delay time.✓ (3)

**[12]**

## QUESTION 2: CONDUCTORS AND CABLES

2.1 K ✓

2.2 F ✓

2.3 A ✓

2.4 J ✓

2.5 B ✓

2.6 I ✓

2.7 G ✓

2.8 C ✓

2.9 H ✓

2.10 D ✓

2.11 E✓ (11 × 1) **[11]**

## QUESTION 3: DC MOTORS AND STARTERS

3.1 3.1.1 Field windings <u>produce the magnetic field</u> that will interact with the armature's magnetic field.✓

3.1.2 Pole shoes <u>distribute the flux evenly over a wider armature area</u> OR keep the field coils in place.✓

3.1.3 Brush-gear <u>holds the brushes in position</u> and pushes them against the commutator.✓ OR
The brush-gear houses and isolates the brushes from the casing.
(3 × 1) (3)

3.2 3.2.1 The field windings are in parallel with the armature in a shunt motor.✓

3.2.2 The field windings are in series with the armature in a series motor.✓

3.2.3 The shunt coil is in parallel with the armature and the series coil in series with the combined shunt and armature.✓
(3 × 1) (3)

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3.3 3.3.1 False✓

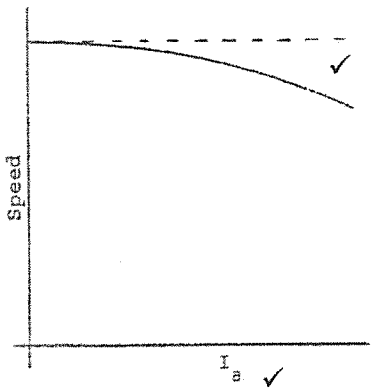
3.3.2 False✓

3.3.3 False✓

3.3.4 False✓

(4 × 1) (4)

3.4 Correct shape of curve = 1
Correctly labelled axis = 1




(2)
**[12]**

## QUESTION 4: AC MOTORS AND STARTERS

4.1 4.1.1 The stator produces the main magnetic field.✓

4.1.2 Slip rings transfer current to and from the rotating coils.✓

4.1.3 Terminal box houses the coil terminals so that connections to them can be made inside the box.✓

(3 × 1) (3)

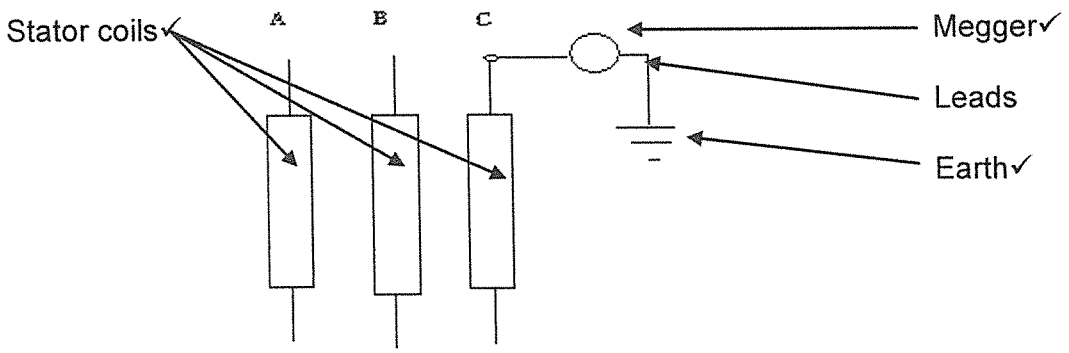
4.2 4.2.1 Energy is transferred magnetically from the stator to the rotor.✓

4.2.2 The resultant magnetic field rotates around the stator frame in induction motors because of the 120° (electrical) phase differencebetween the three-phase voltages as well as the physical angle (around the stator) between the coils.✓

4.2.3 The supply frequency and the number of poles determine the speed of rotation of the magnetic field.✓

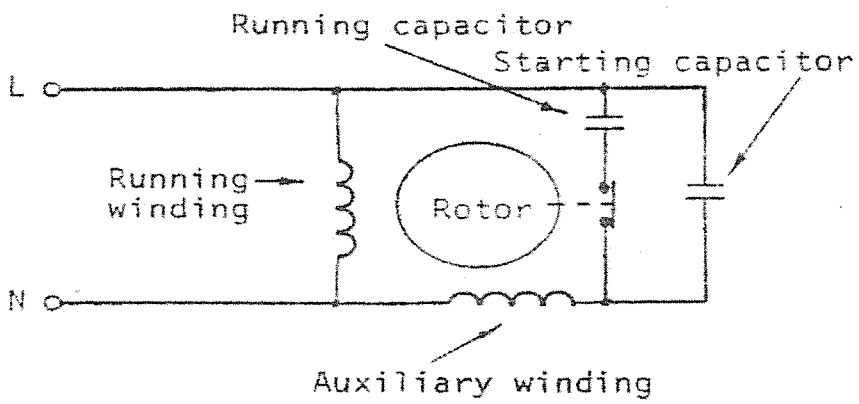
(3 × 1) (3)

4.3




Disconnect the stator coils. ✓ Connect one megger lead to one side of the stator coil of the motorand then connect the other lead to earth. The reading should be above 500 kΩ. ✓ (5)

4.4




correct✓✓

cap +centr. switch ✓

2nd cap✓

(4)
**[15]**

## QUESTION 5: EARTHING

5.1 5.1.1 The purpose of earthing is to guard every electrical installation, machine, and appliance apparatus✓ against the effect of leakage currents, static charges or lightning discharges✓. (2)

5.1.2 A floating earth point is where non-current carrying✓ conducting parts are connected together, thus forming a common zero volt✓ potential. (2)

5.2 5.2.1 Protective conductor forms part of a low-voltage supply and connects the source earth✓ to the consumer's earth terminal✓. (2)

5.2.2 Bonding is when all non-current carryingconducting parts are connected together by means of clamps✓ and an earth continuity conductor✓. (2)

5.3 Earthing of the power systems such as the star point of transformers and alternatorsto provide surge protection ✓ and for other protection devices to function properly.✓ (2)

5.4 Where – in substations normally buried underground.✓
For what purpose - to provide a good earth (effective earthing).✓ (2)
**[12]**

## QUESTION 6: PROTECTION

6.1 6.1.1 In a multiphase installation, the loads connected to each phase should, as far as is practical, be balanced✓. (1)

6.1.2 Varistors are non linear voltage dependant resistors✓. (1)

6.1.3 The purpose of an earth leakage relay is to detect an earth fault ✓ and to automatically disconnect the installation or circuit from the supply✓ (2)

6.1.4 Earth leakage protection must disconnect when the imbalance between live and neutral is in the range of 15mA✓ to 30mA✓. (2)

6.2 6.2.1 Surge arrestors are devices that will, once their rating is reached, provide a path for currents caused by surges✓ and overvoltages to flow to earth ✓. (2)

6.2.2 HRC fuses are high rupturing capacity fuses that open the circuit✓ when the fuse rating is reached✓.
(2)
**[10]**

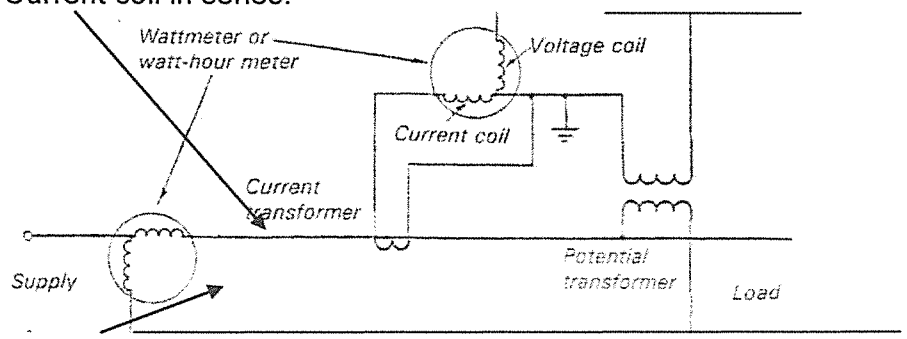
## QUESTION 7: MEASURING INSTRUMENTS

7.1 7.1.1 Measures effective power consumed in kWh and the highest average power in kW (or kVA) during the time period of metering. ✓

7.1.2 Measures frequency in Hz in AC supplies or circuits. ✓

7.1.3 Measures power or the rate at which electrical energy is consumed in watts. ✓
(3 × 1) (3)

7.2 Both types of connections accepted
Current coil in series. ✓




Voltage coil in parallel. ✓ Supply and load. ✓ (3)
**[6]**

## QUESTION 8: TRANSFORMERS

8.1 The primary phase voltage = The primary line voltage
$V_{p\,ph}$ = 11 000 V ✓
= 11 kV (must have units) (1)

8.2 The secondary line voltage = The secondary phase voltage x$\sqrt{3}$
$V_{p\,ph}$ = 220 x $\sqrt{3}$✓
= 381 V ✓ (must have units) (2)

8.3 The primary phase current = $I_{p\,L}/\sqrt{3}$
$I_{p\,ph}$ = 120 / $\sqrt{3}$✓
= 69,28 A ✓ (2)

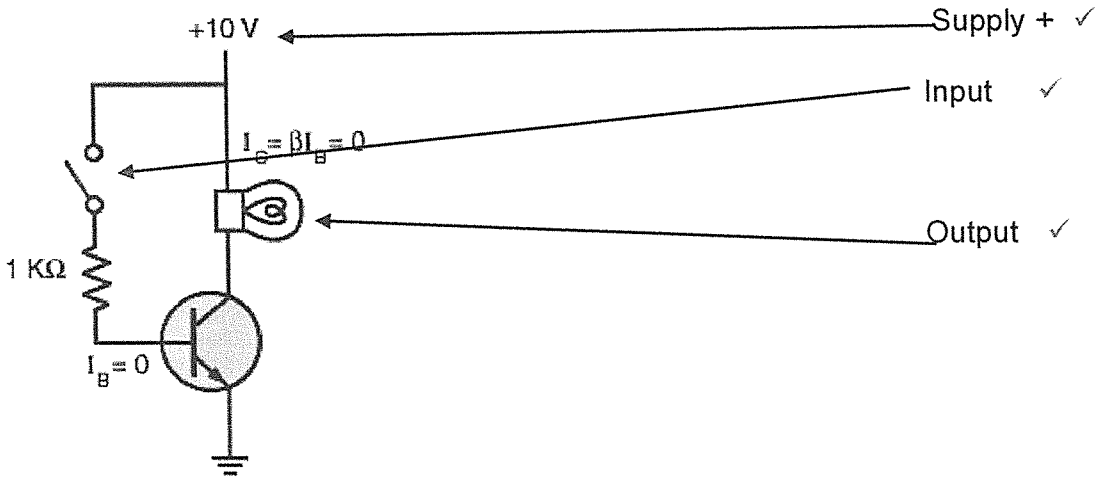
8.4 The secondary phase current = The primary phase current x turns ratio
turns ratio = $V_{p\,ph}/V_{s\,ph}$✓
= 11 000/220
= 50:1 ✓
Thus $I_{s\,ph}$ = 69,28 x 50✓
= 3 464 A ✓ (4)

8.5 The full-load rating = $\sqrt{3}$x $V_{p\,L}$ x $I_{p\,L}$✓
= $\sqrt{3}$11 000. 120 ✓
= 2 286 307 VA✓
= 2,286 MVA (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)

9.2




(3)

9.3 Alternating 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**

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