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T460(E)(A5)T
APRIL EXAMINATION
NATIONAL CERTIFICATE
ELECTRICAL TRADE THEORY N3
(11041263)
5 April 2016 (X-Paper)
09:00–12:00

This question paper consists of 9 pages and 1 formula sheet.
DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA
NATIONAL CERTIFICATE
ELECTRICAL TRADE THEORY N3
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. 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.
QUESTION 1: DOMESTIC APPLIANCES

1.1 A stove using 40 A must be installed in a new house.

Explain the procedure of installing a stove, type of materials used and placement of parts. Start from the distribution board to the stove's screw connectors. (4)

1.2 Explain how you would test each circuit (plate number 1 and oven) of the above stove for continuity with the aid of an ohm-meter. (3)

1.3 Draw the single phase sub-circuit that adheres to wiring code regulations that would supply the stove with power. (3)

QUESTION 2: PROTECTION

2.1 Name the conductors in a single-phase domestic installation that the earth-leakage relay disconnect when the earth-leakage protection is activated. (2)

2.2 State what value of 220 V AC current is it considered dangerous to humans (2)

2.3 FIGURE 2.1 shows a Balanced Core Earth Leakage Relay.

Explain the operating principle of a core balance earth-leakage relay.

![Balanced Core Earth Leakage Relay Diagram](image_url)
QUESTION 3: ILLUMINATION

3.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only ‘true’ or ‘false’ next to the question number (3.1.1–3.1.5) in the ANSWER BOOK.

3.1.1 A fluorescent tube emits light because of a continuous electric arc in the tube.  
3.1.2 Gasses used in discharge lamps have a positive temperature coefficient of resistance and the current needs to be limited as the temperature increases. 
3.1.3 Phosphor powder is used in lamps because it has a long afterglow. 
3.1.4 Rotating machinery give a stroboscopic effect under incandescent lamps. 
3.1.5 When compared with discharge lamps, tungsten halogen lamps emit bright light but consume a higher amount of energy.  

3.2 Draw a labelled circuit diagram of a fluorescent lamp that is started with the aid of a glow starter. (You will lose marks if the components are not labelled.)

QUESTION 4: ALTERNATING CURRENT THEORY

4.1 FIGURE 4.1 shows a sine wave. NOTE: The angle is in degrees.

\[ e = 310 \sin(18 \,000\,t) \, \text{Volts} \]

**FIGURE 4.1: SINE WAVE**

4.1.1 Calculate the waveform's effective value.  
4.1.2 Redraw the waveform indicating the RMS, peak and Average Values on the waveform correctly.
4.2 Draw a phasor diagram that will represent a balanced three phase voltage supply. Indicate on the diagram the following:
- Correct order of Phases if the reference point is at 0°
- Correct Direction of Rotation
- Correct phase angle between phases
- Current in each phase lagging the voltage – Exact scale is not required.

QUESTION 5: SERIES RLC CIRCUITS

5.1 FIGURE 5.1 shows an RLC Circuit. Answer the following questions.

FIGURE 5.1: RLC CIRCUIT

5.1.1 Calculate the inductive reactance
5.1.2 Calculate the circuit impedance.
5.1.3 Sketch a fully labelled phasor diagram.

QUESTION 6: THREE-PHASE AC SYSTEMS

6.1 Calculate the power in balanced 3-phase delta connected system with the following information:
- Line Voltage = 420 Volt
- Line Current = 23A
- Φ=9°
- Load = inductive

6.2 Calculate the line voltage between two phases in a star connected system if the phase voltage between one phase and neutral is 220 V.

6.3 Figure 6.1 shows a block diagram representing the losses in a 3-phase motor. Calculate the output power of the motor from the given information.
QUESTION 7: TRANSFORMERS

7.1 The circuit in FIGURE 7.1 below consists of three single-phase transformers connected together. This circuit is connected to a three-phase 380 V supply. The primaries are labelled with capital letters.

7.1.1 Identify the configuration in which the transformer is connected from primary to secondary. (2)

7.1.2 State whether this is a step up / step down transformer. (1)

7.1.3 Identify the Neutral connector/s on the transformer (1)

7.2 Calculate the output line voltage of a delta/delta step up transformer if the transformer has a turns ratio of 1:10 and an input line voltage of 380 Volts. (3)

7.3 A current of 2 A at a power factor of 0.8 is drawn from the 380 V supply when a transformer is connected to a balanced three-phase load.

Calculate the total power consumed. (3)
QUESTION 8: DC MACHINES

8.1 Name the functions of the following components of a DC motor circuit:

8.1.1 A variable resistor placed in series with the armature of a shunt motor

8.1.2 A no-volt release coil

8.1.3 An overload relay

(3 x 1) (3)

8.2 Name any TWO types of field-coil connections used in DC motors. (2)

8.3 Name any TWO methods to reduce armature reaction with reference to DC motors. (2)

8.4 Explain how you would do a field volt-drop test on a four-pole DC motor. (3)

[10]
QUESTION 9: AC MACHINES

9.1 Explain why the running winding of a split-phase motor has a lower resistance and lower inductive reactance than the starting winding. (2)

9.2 Draw a circuit diagram of a split-phase motor that has one capacitor which is permanently connected during operation. (3)

9.3 State the code of practice on motor circuits regarding the starter circuit of a large DC motor and loss of supply. (1)

9.4 Explain how the slip-ring motor in FIGURE 9.1 below is started and how it reaches full speed. (4)

![Figure 9.1: Slipring Motor Starter](image_url)
QUESTION 10: MEASURING INSTRUMENTS AND ELECTRONICS

10.1 Explain how you would increase the range of the following instruments:

10.1.1 A DC ammeter (1)
10.1.2 A DC voltmeter (1)
10.1.3 An AC wattmeter (3)

10.2 Define each of the following terms:

10.2.1 Electron current flow (5 x 1)
10.2.2 Semi-conductor
10.2.3 Positive ions
10.2.4 P-type doping (5)
10.2.5 Pentavalent atom

TOTAL: 100
FORMULA SHEET

\[ I_T = \frac{V}{Z} \]
\[ I_{ACTIVE} = I_T \cos \phi \]
\[ I_{REACTIVE} = I_T \sin \phi \]
\[ X_L = 2\pi f L \]
\[ X_C = \frac{1}{2\pi f C} \]
\[ Z = \sqrt{R^2 + (X_L - X_C)^2} \]
\[ \phi = \cos^{-1} \left( \frac{R}{Z} \right) \]
\[ V_R = I_T R \]
\[ V_{XL} = I_T X_L \]
\[ V_{XC} = I_T X_C \]
\[ V = \sqrt{V_R^2 + (V_{XL} - V_{XC})^2} \]
\[ P = I_T^2 R \]
\[ S = VI \]

3-phase
\[ P = \sqrt{3} V_L I_L \cos \phi \]
\[ S = \sqrt{3} V_L I_L \]

DELTA
\[ V_L = V_{PH/F} \]
\[ I_L = \sqrt{3} I_{PH/F} \]

STAR
\[ V_L = \sqrt{3} V_{PH/F} \]
\[ I_L = I_{PH/F} \]

\[ \frac{V_p}{V_s} = \frac{N_p}{N_s} = \frac{I_s}{I_p} \]
\[ \omega = 2\pi f \]
\[ N = \frac{f \cdot 60}{p} \]
\[ s = \frac{n - n_r}{n} \]

The next five formulae are true for voltage

\[ i = I_m \sin (\omega t) \]
\[ I_{rms} = 0,707 I_m \]
\[ I_{ave} = 0,637 I_m \]
\[ I_{rms} = \frac{i_1^2 + i_2^2 + \ldots + i_n^2}{n} \]
\[ I_{ave} = \frac{i_1 + i_2 + \ldots + i_n}{n} \]

Form factor = \frac{RMS-value}{AVE-value}
Crest factor = \frac{MAX-value}{RMS-value}

SERIES
\[ R_T = R_1 + R_2 + \ldots + R_n \]

PARALLEL
\[ \frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n} \]
This marking guideline consists of 8 pages.
NOTE: 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 must analyse the student’s solution to determine if the question has been answered and therefore must not adhere strictly to this memorandum.

QUESTION 1: DOMESTIC APPLIANCES

1.1 • 25 mm conduit installed from D.B to stove.
• Isolator box not more than 0,5 m from stove.
• Flexible conduit between wall and stove.
• 6 mm² L, N and E conductors from D.B to stove.

1.2 • Make sure the disconnector is off.
• Place meter on ohms scale and measure between live and neutral.
• Switch the stove plate or the oven on.
• Ohms value should be low.

1.3

![Diagram of electrical connections]

Distribution Board

Live
Neutral
Earth

MCB for Stove

Stove

Live
Neutral
Earth

Stove Disconnector

QUESTION 2: PROTECTION

2.1 Live ✓ and neutral. ✓

2.2 Approximately 20 mA ✓ and higher. ✓

2.3 • When the live and neutral wire current is the same, ✓ the magnetic fields cancel each other since the current flows in opposite directions. ✓
• No EMF will be induced in the secondary. ✓
• If an earth fault occurs, the live will carry more current than the neutral ✓ and
• at 20 mA ✓ the resultant field will be strong enough to activate the relay. ✓
QUESTION 3: ILLUMINATION

3.1
- 3.1.1 False
- 3.1.2 False
- 3.1.3 True
- 3.1.4 False
- 3.1.5 True

(5 x 1) (5)

3.2

QUESTION 4: ALTERNATING CURRENT THEORY

4.1
- 4.1.1 \( V_{RMS} = V_{Maximum} \times 0.707 \checkmark \)
  - \( V_{RMS} = 310 \times 0.707 \checkmark \)
  - \( V_{RMS} = 219.17 \text{ Volt} \checkmark \)

(3)

4.1.2

\( V_{(Maximum)} \checkmark \)
\( V_{(RMS)} = V_{(Maximum)} \times 0.707 \checkmark \)

\( V_{(Average)} = V_{(Maximum)} \times 0.637 \)
Over \( \frac{1}{2} \) cycle

(3)
4.2

\[ L_1 \rightarrow 0^\circ \]

\[ I_1 \rightarrow 0^\circ \]

\[ I_2 \rightarrow 120^\circ \]

\[ I_3 \rightarrow 120^\circ \]

\[ L_2 \rightarrow \]

\[ L_3 \rightarrow \]

\[ (4) \]

\[ [10] \]
QUESTION 5: SERIES RLC CIRCUITS

5.1 5.1.1 \( X_L = 2 \pi f L \checkmark \)
\( X_L = 2 \pi 50 \times 0.1 \checkmark \)
\( X_L = 31.4 \Omega \checkmark \)

5.1.2
\( Z = \sqrt{R^2 + (X_L)\times (X_C)^2} \checkmark \)
\( Z = \sqrt{5^2 + (31.4 \equiv 27.65)^2} \checkmark \)
\( Z = \sqrt{25 + (3.75)^2} \)
\( Z = 6.25 \Omega \checkmark \)

5.1.3
\[ V_{X_L} = V_{XL} - V_{XC} \]
\[ V_X = 6.25 \checkmark \]

Note to Marker
Must show lagging p.f OR \( X_L \gg X_C \]
\( V_Z \) leads \( I_Z \)
\( \Phi \) = angle between \( V_Z \) and \( V_R \)

[10]
QUESTION 6: THREE-PHASE AC SYSTEMS

6.1 \[ P = \sqrt{3} \times V_l \times I_l \times \cos \Phi \]
\[ P = \sqrt{3} \times 420 \times 23 \times \cos 9^\circ \]
\[ P = 16525.619 \text{ Watt} \]  

6.2 \[ V_L = \sqrt{3} \times V_{ph} \]
\[ = \sqrt{3} \times 220 \]
\[ = 381 \text{ V} \]  

6.3 \[ P_{in} = \sqrt{3}V_{LL} \cos \Phi \times \eta \]
\[ = \sqrt{3} \times 380 \times 42.2 \times 0.8 \times 0.9 \]
\[ = 19998.12 \text{ Watt} \]
\[ \eta = 90\% = 0.9\]  
If candidate can show 90% efficiency = 0.9 as a factor of 1 = fourth mark is awarded.  

QUESTION 7: TRANSFORMERS

7.1 7.1.1 Delta\( \checkmark \): Star\( \checkmark \) connected transformer  
Note: Order must be correct  

7.2 Step down transformer\( \checkmark \). 550:1 indicates 550 turns for every 1 turn on the secondary  

7.3 Neutral = 4\( \checkmark \)  

7.4 \[ V_{a1a2} = V_{A1A2} \div T.R \]
\[ = 380 \div 1/10 \]
\[ = 3800 \text{ V} \]  

7.5 \[ P = \sqrt{3} \times V_L \times I_L \cos \phi \]
\[ = \sqrt{3} \times 380 \times 2 \times 0.8 \]
\[ = 5.77 \text{ A} \]  

[10]
QUESTION 8: DC MACHINES

8.1 8.1.1 For speed control  
8.1.2 To disconnect the motor when the supply voltage is too low  
8.1.3 To trip when the motor draws too much current  

8.2  
- Shunt  
- Series  
- Combination of series and parallel  

8.3  
- Brush shifting  
- Interpoles  
- Compensating windings, add a series field.  

8.4  
- Connect the 4 windings in series to a low voltage supply.  
- Use a voltmeter to measure the voltage across each winding.  
- The readings should be the same across all the poles.  

QUESTION 9: AC MACHINES

9.1 The running winding has less turns\(\checkmark\) in the coils than the starter winding, but it is of a thicker wire, thus having less inductance and less resistance\(\checkmark\), ergo less reactance.  

9.2

Note to marker:  
- Must show Centrifugal switch in series with starter capacitor and labelled.  
- Run Cap must be permanently connected in circuit and labelled.  
- Main Winding / run Winding in parallel with supply
9.3 The starting arm must move back to the OFF position during loss of supply. (1)

9.4 • The motor will only start up if the resistors are in circuit
    • and the brushes are on (short-circuit rings open).
    • As the motor gains speed the resistors are gradually removed from the circuit.
    • Once removed, the slip rings are short-circuited. (4) [10]

QUESTION 10: MEASURING INSTRUMENTS AND ELECTRONICS

10.1 10.1.1 Insert a shunt resistor (parallel to meter) into the circuit. (1)
    10.1.2 Insert a resistor in series with the meter. (1)
    10.1.3 • Use instrument transformers.
         • The secondary of a current transformer supplies the current coil of the meter and
         • the secondary of a potential transformer supplies the voltage coil of the meter (3)

10.2 10.2.1 Flow of electrons in the external circuit (not in the battery) from negative pole to positive pole.
    10.2.2 Material with special properties and electrical resistance between a conductor and an insulator.
    10.2.3 Atoms with fewer electrons than protons.
    10.2.4 An impurity added to Si or Ge that has only 3 valence electrons.
    10.2.5 An atom that has 5 valence electrons (electrons available for bonding). (5 x 1) (5)

[10]

TOTAL: 100
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