higher education & training

Department:
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REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N3

(8080613)

20 November 2024 (X-paper)
09:00–12:00

Drawing instruments and non-programmable calculators may be used.

This question paper consists of 8 pages and 1 formula sheet.

040Q1E2420

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
INDUSTRIAL ELECTRONICS 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. The answer of a calculation must be given to THREE decimals after the comma.
5. All calculations must have the following three steps:
    1. The formula
    2. The replacement of values
    3. The answer and the correct SI unit
6. Use only a black or blue pen.
7. Diagrams and drawings must be neat and labelled. Drawing instruments and a pencil may be used.
8. Write neatly and legibly.

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SECTION A

QUESTION 1

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 Forced commutation is used in direct current SCR circuits.

1.1.2 The collector current of a transistor will increase when the base/ emitter forward-bias voltage is increased.

1.1.3 Kirchhoff's laws are applied to AC circuits.

1.1.4 In positive temperature coefficient thermistors, the resistance increases with an increase in temperature.

1.1.5 An operational amplifier has the ability to handle both alternating-current and direct-current signals.

(5 × 1) (5)

1.2 Complete the following sentence or sentences or paragraphs by choosing a word or words from the list below. Write only the answer next to the question number (1.2.1–1.2.5) in the ANSWER BOOK.

minimum; one; photosensitive; dual-beam; unmonitored; piezoelectric; maximum; dual-trace; zero; monitored

1.2.1 The impedance of a parallel resonant circuit is at its … value.

1.2.2 An open loop control system is a type of control system in which the output is …

1.2.3 When both inputs of an operational amplifier are equal, the output will be …

1.2.4 A … oscilloscope has two electron guns.

1.2.5 Crystal transducers make use of the … effect.

(5 × 1) (5)

1.3 Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question number (1.3.1–1.3.5) in the ANSWER BOOK.

1.3.1 A Darlington pair is ...

A a very good current amplifier.
B normally associated with high-frequency applications.
C a very good voltage amplifier.
D a fast-switching amplifier.

1.3.2 Transients are at their worst when the SCR is switched on at …

A 30°
B 45°
C 90°
D 180°

1.3.3 The smallest change in measured value to which an instrument will respond is called …

A sensitivity.
B resolution.
C accuracy.
D precision.

1.3.4 The total impedance of a series RLC circuit …

A is equal to the sum of the values of resistance, inductive reactance and capacitive reactance.
B always increases as the applied frequency increases.
C is the minimum at the resonant frequency.
D always increases as the applied frequency decreases

1.3.5 A transistor has an emitter current of 25 mA and a collector current of 22 mA.

The base current is …

A 15 mA
B 3 mA
C 23 mA
D 8 mA

(5 × 1) (5)
[15]

TOTAL SECTION A: 15

SECTION B

QUESTION 2: DC THEORY AND AC THEORY

2.1 Study FIGURE 1 and determine the following with the aid of Kirchhoff's laws:

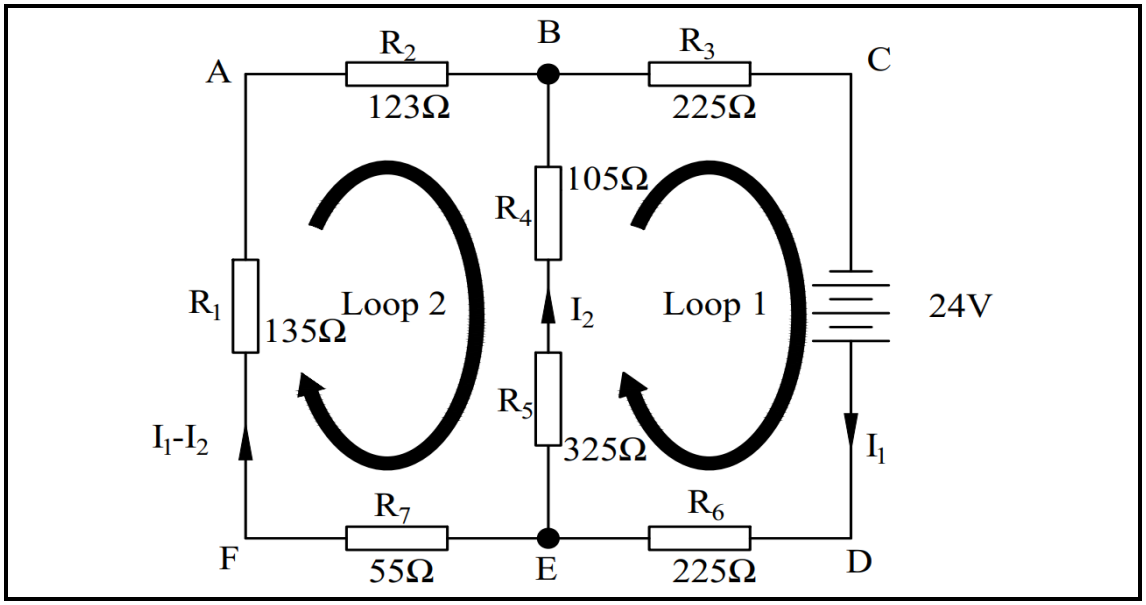


FIGURE 1

2.1.1 The equation for Loop 1 (DEBCD) (2)

2.1.2 The equation for Loop 2 (EFABE) (2)

2.1.3 The magnitude of the currents I_1 and I_2, by making use of the equations in QUESTIONS 2.1.1 and 2.1.2. (6)

2.2 A coil with the resistance of 16 Ω and an inductance of 40 mH is connected in parallel to a capacitor. This circuit is then connected to a 220 V/50 Hz supply.

If the current is at a minimum in the RCL circuit, calculate the value of the capacitor. (10)
[20]

QUESTION 3: SEMICONDUCTOR DIODES AND TRANSDUCERS

3.1 A clipper is a circuit that removes either the positive half or negative half of the input AC signal.

Draw a neat circuit of a shunt positive clipper and indicate the output waveform if an AC signal is applied on the input. (4)

3.2 An LVDT (linear variable differential transformer) is an electromechanical transducer used to convert mechanical motion, specifically rectilinear motion, into a variable electrical current, voltage or electric signals.

3.2.1 Draw a neat, labelled circuit diagram that shows the construction of the LVDT. (3)

3.2.2 Name TWO areas of application of the piezoelectric transducer. (2)

3.2.3 Name TWO types of transducers. (2)

3.3 The Fermi level plays an important role in the band theory of solids. In doped semiconductors, P-type and N-type, the Fermi level is shifted by the impurities that are illustrated by their band gaps.

Make a neat, labelled drawing to illustrate the Fermi level of each of the following types of material:

3.3.1 P-type material

3.3.2 N-type material

(2 × 3) (6)

3.4 An optocoupler (also called an opt isolator) is a semiconductor device that allows an electrical signal to be transmitted between two isolated circuits.

Draw a neat, labelled circuit diagram of an optocoupler using a photodiode and an LED. (4)

3.5 A thermistor is a resistance thermometer, or a resistor of which the resistance is dependent on temperature.

Draw a neat, labelled circuit diagram of the application of a thermistor. (4)

[25]

QUESTION 4: SEMICONDUCTORS, TRANSISTORS AND OPERATIONAL AMPLIFIERS

4.1 Use a NPN transistor and draw the circuit diagram of a parallel voltage regulator. (5)

4.2 State FOUR advantages of a transistor when it is used as a switch. (4)

4.3 Three different input signals must be combined and a single amplified output must be produced from them.

Draw an operational amplifier circuit to use for such a requirement and clearly show the input terminals. (4)

4.4 Draw a labelled block diagram of a shunt-voltage negative feedback with the concept of the feedback resistor being connected across the amplifier. (4)

4.5 State THREE characteristics of operational amplifiers. (3)

4.6 A MOSFET is a junction field effect transistor that has its gate terminal insulated from the channel.

Draw the following regarding an enhanced P-channel MOSFET:

4.6.1 A neat, labelled IEC symbol (2)

4.6.2 A neat, labelled characteristic curve (3)

[25]

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QUESTION 5: MEASURING INSTRUMENTS AND SILICON-CONTROLLED RECTIFIER

5.1 SCR's are mainly used in devices where the control of high power, possibly at high voltage, is needed. The ability to switch large currents on and off makes the SCR suitable for use in medium to high-voltage AC power control applications, such as lamp dimming, regulators and motor control.

Draw and label the construction of a PNPN SCR and explain how an SCR can be turned on by applying a break over voltage switching-on method. (6)

5.2 A sine wave is displayed on the screen of an oscilloscope.

The average value of the voltage of this waveform is calculated as 220 mV.

Calculate the following of the waveform:

5.2.1 Maximum value

5.2.2 RMS value

(2 × 2) (4)

5.3 FIGURE 2 below shows a simplified block diagram of a continious balance digital voltmeter (DVM).

Explain the operation of the following continuous balance DVM block diagram:

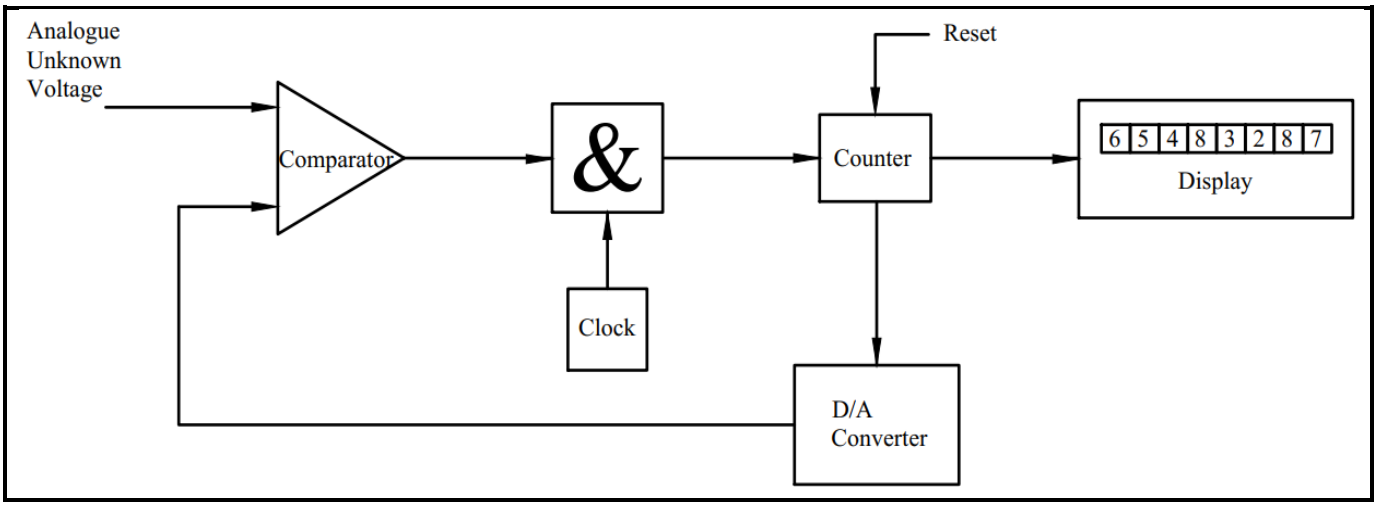


FIGURE 2

(5)
[15]

TOTAL SECTION B: 85
GRAND TOTAL: 100

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(8080613)

INDUSTRIAL ELECTRONICS N3

FORMULA SHEET

DIRECT-CURRENT THEORY

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

$P = I^2 \cdot R$

ALTERNATING-CURRENT THEORY

$X_L = 2\pi fL$ $\quad X_C = \frac{1}{2\pi fC}$ $\quad Z = \sqrt{R^2 + (X_L \sim X_C)^2}$

$V_T = \sqrt{V_R^2 + (V_L \sim V_C)^2}$ $\quad I = \frac{V_T}{Z}$ $\quad \theta = \cos^{-1}\frac{R}{Z}$ $\quad V_{RMS} = \frac{V_{P-P}}{2} \times 0{,}707$

$V = I \cdot R$ $\quad V = I \cdot X_L$ $\quad V = I \cdot X_C$ $\quad V_{AVE} = \frac{V_{P-P}}{2} \times 0{,}637$

$f_r = \frac{1}{2\pi\sqrt{LC}}$ $\quad I_R = \frac{V_T}{R}$ $\quad I_L = \frac{V_T}{X_L}$ $\quad f = \frac{1}{t}$

$I_C = \frac{V_T}{X_C}$ $\quad I_T = \sqrt{I_R^2 + I_X^2}$ $\quad I_X = I_L \sim I_C$

$\theta = \tan^{-1}\frac{I_X}{I_R}$ $\quad \theta = \cos^{-1}\frac{I_R}{I_T}$ $\quad Z = \frac{V}{I_T}$

$Z_D = \frac{L}{RC}$ $\quad I_T = \frac{V}{Z_D}$ $\quad f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$

$I_C = I_{RL}\ Sin\theta_L$ $\quad I_T = I_{RL}\ Cos\theta_L$ $\quad I_T = \sqrt{{I_{T_H}}^2 + {I_{T_V}}^2}$

TRANSISTORS

$I_C = \frac{V_{CC}}{R_L}$ $\quad Rc = \frac{\text{Vcc}}{\text{Ic}}$

TRANSDUCERS

$R = \frac{\rho \cdot l}{a}$ $\quad C = \frac{k \cdot A \cdot E_o}{d}$

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