higher education & training

Department:
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REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N6

(8080186)

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09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

This question paper consists of 8 pages and a formula sheet of 3 pages.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
INDUSTRIAL ELECTRONICS N6
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. Start each section on a new page.
5. Use only a black or blue pen.
6. Write neatly and legibly.

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QUESTION 1: TRANSIENTS

1.1 An RC circuit consists of a 10 KΩ resistor in series with an uncharged 100 µF capacitor, and is powered by a 15 V DC supply. Prove by means of calculations that, at time intervals of one time constant, during the fifth time:

1.1.1 The capacitor voltage rises to V_S. (4)

1.1.2 The voltage across the resistor drops to 0 V. (2)

1.1.3 The charging current is reduced to 0 A. (2)

1.2 Give the names of each of the following:

1.2.1 The mathematical laws that govern the analysis of transient RLC circuits

1.2.2 The electronics laws on which the equations of transient RLC circuits are based

(2 × 1) (2)

[10]

QUESTION 2: TRANSDUCERS

2.1 The concept of unity gain in an operational amplifier denotes a relation between two resistors. Name these TWO resistors and identify the relation between them. (3)

2.2 Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (2.2.1–2.2.5) in the ANSWER BOOK.

2.2.1 In an amplifier multiplier circuit that is connected in the non-inverting mode, the R_F/R_M combination is connected to the inverting input of the op-amp. (2)

2.2.2 In an amplifier multiplier circuit that is connected in the inverting mode, the R_F/R_M combination is connected to the non-inverting input of the op-amp. (2)

2.2.3 When an op-amp is used during offsetting, the linear voltage divider network is connected to the non-inverting input. (1)

2.2.4 When an op-amp is used for voltage-to-current interfacing, the R_1/R_2 combination is connected to the inverting input. (1)

2.2.5 When an op-amp is used for current-to-voltage interfacing, the R_1/R_2 combination is only connected to the inverting input. (1)

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2.3 A voltage-to-current interface amplifier has an input resistor of 20 KΩ and a dropping resistor of 2 KΩ, and is used to couple a 1V–5V system to a 4 mA–20 mA control circuit. Calculate the value of the feedback resistor required. (3)

[13]

QUESTION 3: ULTRASONICS

3.1 Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (3.1.1–3.1.5) in the ANSWER BOOK.

3.1.1 Ultrasonic refers to sound energy at frequencies below the audible range of sound, which has a limit of 20 KHz.

3.1.2 The direct piezo-electric effect only refers to non-conductive materials.

3.1.3 Magnetostriction only refers to non-conductive materials.

3.1.4 Cavitation takes place when ultrasonic energy is generated in a gas.

3.1.5 The converse piezo-electric effect only refers to conductive materials.

(5 × 1) (5)

3.2 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 in (3.2.1–3.2.4) in the ANSWER BOOK.

3.2.1 The propagation properties of ultrasonic energy through liquids are …

A excellent.
B good.
C poor.
D non-existent.

3.2.2 The propagation properties of ultrasonic energy through gasses are …

A excellent.
B good.
C non-existent.
D poor.

3.2.3 The propagation properties of ultrasonic energy through a vacuum are …

A excellent.
B poor.
C non-existent.
D good.

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3.2.4 The propagation properties of ultrasonic energy through solids are …

A excellent.
B good.
C non-existent.
D poor.

(4 × 1) (4)

3.3 Name THREE main physical apparatuses that are required to effect ultrasonic cleaning. (3)

[12]

QUESTION 4: X-RAYS AND RADIO ACTIVITY

4.1 The following data on an X-ray machine is available:

Supply voltage = 90 KV Atomic number = 42
Cathode emission = 1×10^{17} electrons/second
Planck's constant = $6{,}636 \times 10^{-34}$ J/s Electron charge = $1{,}602 \times 10^{-19}$ C
Velocity of light = $2{,}997 \times 10^{8}$ m/s

Calculate the shortest wavelength of X-ray produced. (3)

4.2 Choose the correct term from those in brackets. Write only the answer next to the question number (4.2.1–4.2.5) in the ANSWER BOOK.

4.2.1 Electromagnetic waves travel at the speed of light in (air/a vacuum).

4.2.2 (Hard X-rays/Soft X-rays) have longer wavelengths.

4.2.3 (Soft X-rays/Hard X-rays) have shorter wavelengths.

4.2.4 Absorption of X-radiation by any substance is dependent on the atomic (weight/mass) of the substance.

4.2.5 X-rays are produced by transitions of (inner/outer) electrons that orbit atoms.

(5 × 1) (5)

4.3 Draw and fully label a neat circuit diagram of the Geiger-Müller counter. (6)

[14]

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QUESTION 5: AUTOMATIC INSPECTION TESTING AND NDT

5.1 Give ONE term for each of the following descriptions by writing it next to the question number (5.1.1–5.1.5) in the ANSWER BOOK.

5.1.1 An instrument that is used to determine the thickness or variation thereof of a material.

5.1.2 A deflection system that is based on the reflection of sound waves in a medium.

5.1.3 A deflection system that is based on the reflection of radio waves in the air.

5.1.4 An ultrasonic thickness-gauging method that is suited for straight beam castings.

5.1.5 An ultrasonic thickness-gauging method that is suited for thickness measurement where the two sides of the casting are smooth and parallel.

(5 × 1) (5)

5.2 Name, in any order, FIVE main elements of the block diagram of a basic metal detector unit. (5)

[10]

QUESTION 6: ELECTRONIC POWER CONTROL

6.1 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 in (6.1.1–6.1.4) in the ANSWER BOOK.

6.1.1 Which statement describes open-loop process control?

A Senses the output
B Compares the output
C Auto-corrects
D Does not employ feedback

6.1.2 Which statement describes closed-loop process control?

A Does not employ feedback
B Employs feedback
C Does not employ reference data
D Requires manual corrective operations

6.1.3 Which of the following systems does not form part of follow-up closed-loop control?

A Process control
B Servomechanism
C Regulator system
D Sequential control

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6.1.4 Which of the following does not form part of the development phases of a CAD system:

A Prototype
B Design concept
C Computer
D Task

(4 × 1) (4)

6.2 Draw a neat, labelled block diagram of the forward system, which is a type of a continuous industrial UPS. (7)

[11]

QUESTION 7: ELECTRONIC SAFETY DEVICES

7.1 Consider the construction of a basic photoelectric smoke detector circuit and answer the following questions:

7.1.1 Give any ONE example of a light-sensitive transducer that can be used in the construction of a smoke detector circuit. (2)

7.1.2 Give FOUR examples of circuit components that can be used in the construction of a smoke detector circuit to serve as mediums for transmitting a light beam. (4)

7.2 An optical relay consists of a transmitter and two other components. Name these other TWO components. (2)

7.3 List THREE types of protective elements/circuits that can be used to ensure intrinsic safety. (3)

[11]

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QUESTION 8: THYRISTOR DEVICES AND SCR SPEED CONTROL

8.1 Refer to FIGURE 1 below and the accompanying DATA and answer the following questions:

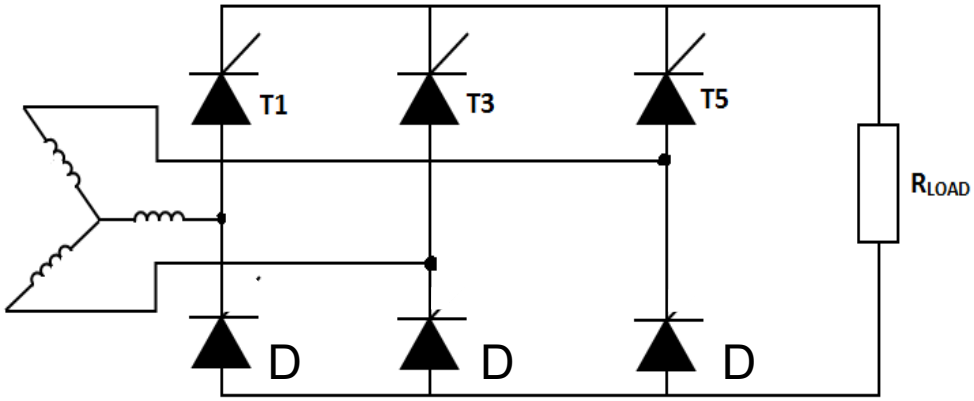


FIGURE 1

DATA: SCR volt drop = 1,5 V each ά = 90º Phase voltage = 180 V

8.1.1 Give the full name of the circuit in FIGURE 1 above. (1)

8.1.2 Name the phase connection in FIGURE 1 above. (1)

8.1.3 Calculate the mean load voltage. (6)

8.1.4 Calculate a suitable PIV rating for the thyristors. (4)

8.2 Name TWO types of AC drives. (2)
[14]

QUESTION 9: PROGRAMMABLE LOGIC CONTROLLERS

Draw a neat, labelled block diagram of a PLC. **[5]**

TOTAL: 100

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$A = B \cdot \left(1 - e^{-t/\tau}\right)$

$A = B \cdot e^{-t/\tau}$

A = Instantaneous value and

B = Maximum value

$V = E \cdot \left(1 - 2e^{-t/\tau}\right) = I \cdot R$ *volts*

$V_D = V_S \left(\frac{R_1}{R_1 + R_2} - \frac{R_3}{R_3 + R_{TH}} \right)$ *volts*

$V_i = \frac{I_L \cdot R_1 \cdot R_D}{R_2} = -\frac{V_o \cdot R_1}{R_2} = \frac{V_o \cdot R_M}{R_M + R_f}$ *volts*

$V_o = -RC \cdot \frac{dV_i(t)}{dt} = -\frac{1}{RC} \int V_i(t)\, dt + V_C(0)$ *volts*

$V_o = \frac{R_2 R_D I_i}{R_1} = -\left[\frac{V_1 R_f}{R_1} + \frac{V_2 R_f}{R_2} + \frac{V_3 R_f}{R_3} + \ldots \right]$ *volts*

Supply rating = Voltage per stage × Number of stages *volts*

$V_{\max} = \sqrt{2} \times V_{rms}$ *volts*

$V_{mean} = 0{,}637 \times V_{\max} = \frac{0{,}637}{2} \times V_{\max}$ *volts*

$V_{mean} = \frac{3 \cdot \sqrt{2}}{\pi} V_{line}$ *volts*

$V_{mean} = \frac{\sqrt{2}}{2 \cdot \pi} V_{rms} \times (1 + Cos\ \alpha)$ *volts*

$V_{mean} = \frac{\sqrt{2}}{\pi} V_{rms} \times (1 + Cos\ \alpha)$ *volts*

$V_{mean} = \frac{2 \cdot \sqrt{2}}{\pi} V_{rms} \times Cos\ \alpha$ *volts*

$V_{mean} = \frac{3 \cdot \sqrt{3}\sqrt{2}}{2 \quad \pi} V_{per\ phase} \times (1 + Cos\ \alpha)$ *volts*

$V_{mean} = \frac{3 \cdot \sqrt{2}}{\pi} V_{line} \times Cos\ \alpha$ *volts*

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$V_{line} = \sqrt{3} \times V_{per\ phase}$ *volts*

$V_{\max} = \sqrt{2} \times V_{line} = \sqrt{2} \times V_{rms}$ *volts*

$I_{rms} = \frac{\sqrt{2}}{2} I_{\max}$ *amps*

$I_{rms} = \frac{\sqrt{2}}{3} I_{\max}$ *amps*

$I_{rms} = \frac{0{,}707}{2} \times I_{\max}$ *amps*

$I_{rms} = I_{peak} \times \sqrt{\frac{\phi}{2 \cdot \pi}}$ *amps*

$I_{peak} = \frac{I_{mean}}{\phi} \times 2\pi$ *amps*

$I_{tube} = Number\ of\ electrons\ per\ second \times q$ *amps*

$I_{max} = Maximum\ safe\ illumination \times Tube\ sensitivity$ *amps*

$Sensitivity = Cathode\ sensitivity \times A$ *amps/lumen*

$P = I^2 \cdot R = V \cdot I = V^2 / R$ *watts*

$X\text{-}ray\ power = P_T \times \eta$ *watts*

$Dissipated\ power = P_T - Power\ used$ *watts*

$\Delta R = R_{TH} \times \Delta t \times temperature\ coefficient$ *ohms*

$Z_{TH} = \frac{T_{rise}}{T_{loss}}$ *ohms*

$R = \frac{T_1 - T_2}{P} = \frac{L}{\tau}$ *ohms*

$f = \frac{1}{t} = \frac{c}{\lambda} = \frac{\omega}{h} = \frac{\omega}{2\pi} = \frac{E \times q}{h}$ *hertz*

$f_r = \frac{1}{2\pi \times \sqrt{LC}}$ *hertz*

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$$f_n = \frac{1}{2\pi} \times \sqrt{\frac{1}{LC} - \left(\frac{R}{2L}\right)^2}$$

hertz

$$\int^{n} = Amplification$$

hertz

$$\int = \frac{\pi \cdot R}{\omega \cdot L}$$

$$C = \frac{t}{R_L} = \frac{\tau}{R}$$

farads

metres

farad

$$d = \frac{v \cdot t}{2}$$

joules

coulombs

meter

$$\omega = 0{,}5 \times C \times V^2 = 0{,}5 \times L \times I^2$$

number of oscillations

joule

per unit

$$q = \frac{h \cdot v}{E \cdot \lambda}$$

Celsius

coulomb

$$n = t \times f = 1 + \frac{\ln 100}{\int}$$

$$\eta = 1{,}4 \cdot 10^{-9} \times E \times Z$$

$$°C_{\max} = V_{i\max} \div V / °C$$

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