higher education & training

Department:
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REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N6

(8080186)

28 November 2023 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

This question paper consists of 7 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. Use only a black or blue pen.
5. Write neatly and legibly.

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QUESTION 1: TRANSIENTS

1.1 In a simple series RC circuit, R = 100 kΩ and C = 22 nF, and the supply is 10 V. How long will it take for the capacitor voltage to rise to 6,32 V if the capacitor was initially discharged? (3)

1.2 A critically damped RLC circuit has R = 10 Ω and L = 2 H. Calculate the value of the capacitance. (3)

1.3 A fluorescent lamp has a coil with 3-H inductance and 15-Ω resistance and is powered by a 120-V DC source.

Calculate the following:

1.3.1 The value of the current flowing through the lamp at 85% of full brightness (4)

1.3.2 The value of the current flowing through the lamp at a time of 0,3 seconds after switch-on (3)

[13]

QUESTION 2: TRANSDUCERS

A thermocouple has an output signal of 1 mV per 10 ºC and is required to measure the temperature of a roaster with a temperature range of 100 ºC to 500 ºC. Calculate the value of a suitable metering resistor for an op-amp multiplier to interface with a standard 1-V to 5-V signal range, if given that the feedback resistor is 100 kΩ.

Show all your calculation steps. **[10]**

QUESTION 3: ULTRASONICS

Choose ONE term from the list below for each of the following descriptions and write it next to the question number (3.1–3.10) in the ANSWER BOOK.

magnetostriction; nodal line; cavitation; soft tool tip; oxide film; heated tool tip; feedback circuit; direct piezoelectric effect; acoustic energy; converse piezoelectric effect

3.1 Broken down during ultrasonic welding by the vibratory energy of the transducers

3.2 Found in sound waveforms

3.3 Made up of, among other components, a winding, a resistor and a capacitor

3.4 The only part in a body that remains at rest while the other parts of the body are in a state of vibration

3.5 A unique property of a conductive material, such that the material will undergo dimensional changes when subjected to magnetic fields

3.6 A process that results in the variation of dimensions of non-conductive crystals under the influence of magnetic fields

3.7 A process whereby high-energy bubbles form and collapse within the cleaning fluid

3.8 When a non-conductive crystal accumulates a small electric charge due to exposure to an oscillating mechanical stress

3.9 An attachment that is connected to the coupling cone of an ultrasonic drill

3.10 An attachment that is connected to the coupling cone of an ultrasonic soldering iron

(10 × 1) **[10]**

QUESTION 4: X-RAYS AND RADIO ACTIVITY

Analyse the following data for a photomultiplier tube, and then answer the questions that follow:

Cathode sensitivity = 33 µA/lumen
I_{max} = 3,3 mA
Number of stages = 6
Emission factor = 4
Volts per stage = 165 V

Calculate the following:

4.1 The amplification (2)

4.2 The supply rating (2)

4.3 The tube sensitivity (2)

4.4 The maximum safe illumination (3)
[9]

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QUESTION 5: AUTOMATIC INSPECTION TESTING AND NDT

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 (5.1.1–5.1.5) in the ANSWER BOOK.

Refer to FIGURE 1 below to answer the questions.

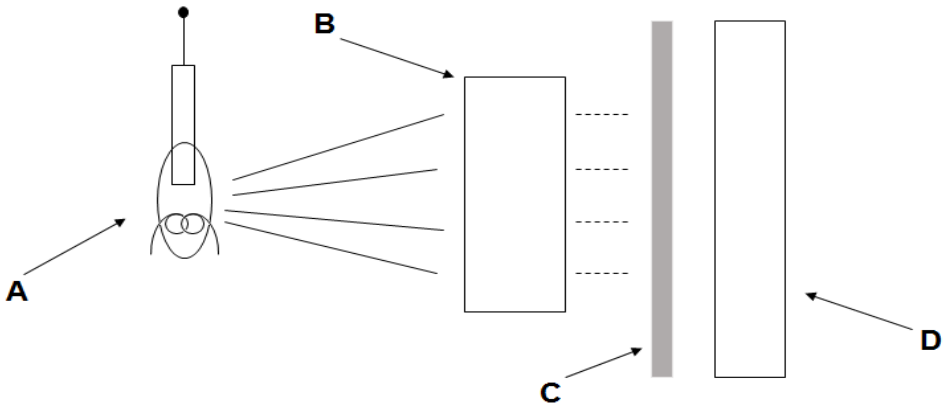


FIGURE 1

5.1.1 The full name of the non-destructive testing method in FIGURE 1 above is …

A direct viewing.
B indirect viewing.
C image intensifier.
D straight-view testing.

5.1.2 The name of the part labelled **A** in the figure is …

A X-ray film.
B X-ray tube.
C screen.
D specimen.

5.1.3 The name of the part labelled **B** in the figure is …

A X-ray film.
B X-ray tube.
C screen.
D specimen.

5.1.4 The name of the part labelled **C** in the figure is …

A X-ray film.
B X-ray tube.
C screen.
D specimen.

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5.1.5 The name of the part labelled **D** in the figure is …

A X-ray film.
B X-ray tube.
C screen.
D specimen.

(5 × 1) (5)

5.2 State TWO main reasons why metal detectors are used in the manufacturing industry. (2)
[7]

QUESTION 6: ELECTRONIC SAFETY DEVICES

Draw neat, labelled circuit diagrams of the following devices that are used to effect intrinsic safety in the engineering industry:

6.1 Shunt protective elements (3)

6.2 Zener barrier protection (9)
[12]

QUESTION 7: ELECTRONIC POWER CONTROL

7.1 In an uninterruptable power supply system, give the name of the sub-circuit that changes AC power to DC power. (1)

7.2 In an uninterruptable power supply system, give the name of the sub-circuit that changes DC power to AC power. (1)

7.3 Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (7.3.1–7.3.2) in the ANSWER BOOK.

7.3.1 In a forward-type UPS system, the primary source of power supplied to the load is from the mains supply.

7.3.2 In a reverse-type UPS system, there is no interruption of power to the load in the event of a power failure.

(2 × 1) (2)

7.4 Draw a neat, labelled block diagram of a UPS system in which a switchover time is acceptable in the event of a power failure. Also provide the name of this UPS system. (9)
[13]

QUESTION 8: THYRISTOR DEVICES AND SCR SPEED CONTROL

An SCR is connected in series with a resistor of 40 Ω and an inductor of 1 H, and this trigger circuit is supplied by a 200-V DC source. If the latching current is 40 mA and the trigger pulse used has a width of 100 µs, deduce by way of calculations and supported by logical reasoning whether the SCR will be triggered or not. **[12]**

QUESTION 9: PROGRAMMABLE LOGIC CONTROLLER

A garden sprinkler is to be switched on and off from either of two locations. Each location must have its own start and stop button. Design a ladder logic diagram that will fulfil this desired control mechanism. **[14]**

TOTAL: 100

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INDUSTRIAL ELECTRONICS N6

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

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

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

metre

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

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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