higher education & training

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INDUSTRIAL ELECTRONICS N6
(8080186)

7 April 2020 (X-paper)
09:00–12:00

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134Q1A2007

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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. Write neatly and legibly.

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QUESTION 1: TRANSIENTS

The following data has been extracted from a DC-powered experimental RL circuit:

V_{SUPPLY} = 100 V Time constant = 1,5 ms Coil current after 1 ms = 0,15A

Calculate each of the following if the coil is initially de-energised.

1.1 Final current through coil (4)

1.2 Resistance value in circuit (3)

1.3 Inductance value in coil (3)

1.4 Energy stored in fully energised coil (2)

[12]

QUESTION 2: TRANSDUCERS

The bridge circuit in FIGURE 1 provides an excitation signal to activate an alarm system.

If R_{TH} has a nominal resistance of 50 Ω at 0 0C and a temperature coefficient of resistance of 0,00193 Ω/Ω/0C, calculate the voltage of the sensor when temperature is 100 0C.

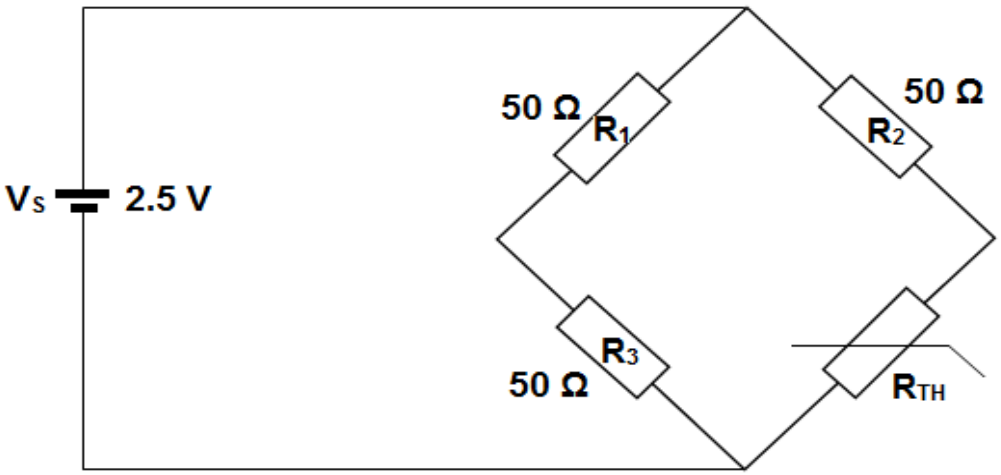


FIGURE 1 **[10]**

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 (3.1.1–3.1.6) in the ANSWER BOOK.

3.1.1 In an ultrasonic cleaning apparatus the transducers are situated on the inside of the cleaning tub.

3.1.2 During an ultrasonic machining process the workpiece is immersed in a suspension of abrasive powder and water.

3.1.3 During an ultrasonic machining process the cutting fluid and the tool tip carry out the actual cutting.

3.1.4 During the ultrasonic soldering process the oxide film does not prevent the solder from adhering to the surfaces to be soldered together.

3.1.5 During the ultrasonic welding process the oxide films are broken down by the vibratory energy of the ultrasonic transducers.

3.1.6 Ultrasonic cleaning, machining and soldering are similar in that they all use a tool tip attached to the coupling cone.

(6 × 1) (6)

3.2 The statements below describe the properties of the cleaning fluid used during the ultrasonic cleaning process.

State the specific reason for each property.

3.2.1 The cleaning fluid should hold the dirt in suspension.

3.2.2 The cleaning fluid should possess good wetting properties.

3.2.3 The surface tension of the cleaning fluid should be low.

(3 × 1) (3)

[9]

QUESTION 4: X-RAYS AND RADIO ACTIVITY

4.1 X-rays contain energy in the form of photons.

Calculate the energy contained within a photon of radiant light travelling at 3 × 108 ms. Use Plank's constant of 6,63 × 10-34 J/S, an electron charge of 1,602 × 10-19 C and a wavelength of 325 × 10-9 m. (5)

4.2 FIGURE 2 shows a circuit diagram of a key radiation detector.

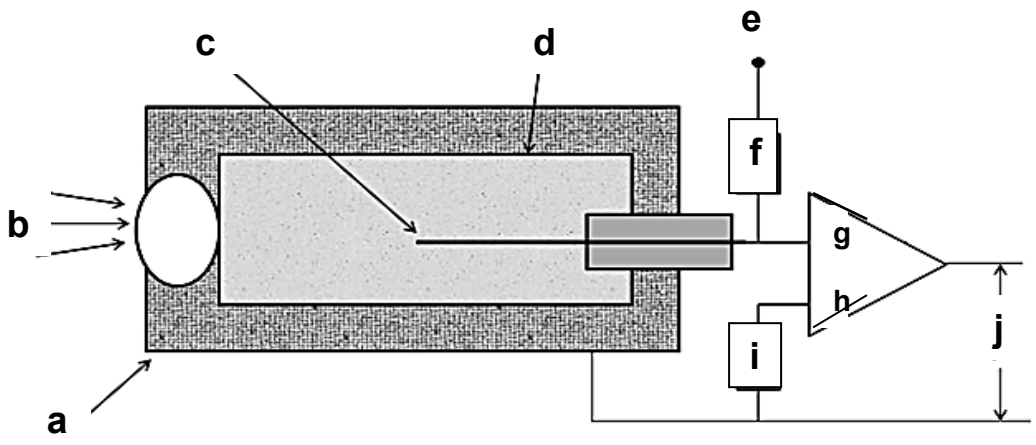


FIGURE 2

4.2.1 Write down the full name of the detector, as well as the category in which the detector falls. (2)

4.2.2 Identify the parts of the detector by writing the answer next to the letter (a–j) in the ANSWER BOOK. (10 × ½) (5)

[12]

QUESTION 5: AUTOMATIC INSPECTION TESTING AND NDT

5.1 Label the generic block diagram of an automatic inspection, testing and grading system shown in FIGURE 3 by writing the answer next to the letter (a-l) in the ANSWER BOOK.

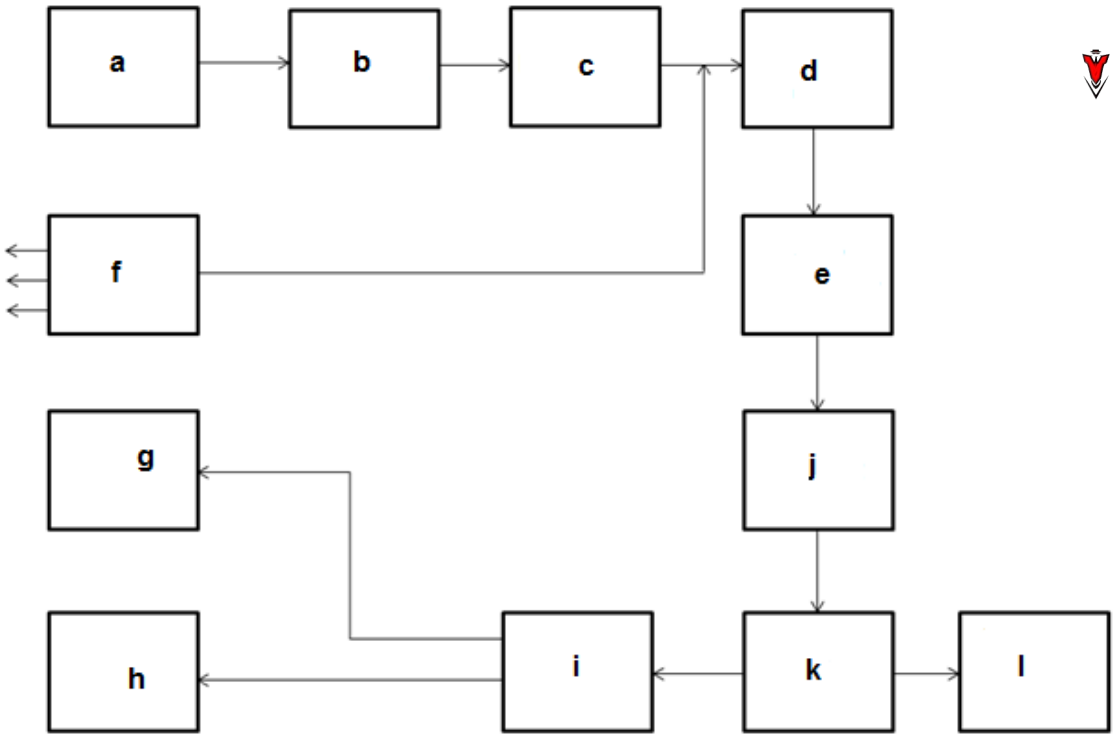


FIGURE 3

(12 × ½) (6)

5.2 Choose the correct term from those in brackets. Write only the answer next to the question number (5.2.1–5.2.5) in the ANSWER BOOK.

5.2.1 A (hi-go-low/go-no-go) system sorts any rejected items into either waste or recyclable items.

5.2.2 A metal detector operates on the principle of employing a (search coil/capacitive transducer) in an oscillator circuit to detect the presence of metallic objects in the vicinity.

5.2.3 The use of ultrasonic for NDT employs the (sonar method/direct-viewing method) to detect flaws on the casting.

5.2.4 The use of X-ray tubes for NDT employs the (direct-viewing method/resonance method) to detect flaws on the casting.

5.2.5 Radar is a concept that is dependent on (reflection/refraction) of radio waves in the air.

(5 × 1) (5)

[11]

QUESTION 6: ELECTRONIC SAFETY DEVICES

One of the possible answers to each question below is incorrect. Choose the incorrect answer and write only the letter (A–D) next to the question number (6.1–6.6) in the ANSWER BOOK.

6.1 The purpose of fitting electronic safety devices in industry is to …

A prevent injuries to workers.
B prevent damage to machinery.
C prevent workers from working overtime.
D prevent death of workers.

6.2 An optical relay of a photo-electric safety device must consist of the following devices:

A Rejecter device
B Medium device
C Receiver device
D Transmitter device

6.3 In determining intrinsic safety the energy levels are divided into …

A zone 3: non-hazardous
B zone 2: least hazardous
C zone 1: hazardous
D zone 0: most hazardous

6.4 On shunt-protective elements shunting is achieved by means of …

A diodes.
B resistors.
C capacitors.
D transistors.

6.5 The steps involved when determining intrinsic safely are …

A transistor construction.
B evaluation.
C circuit analysis.
D construction review.

6.6 To effect intrinsic safety … are used.

A series protective elements
B positive and negative protective elements
C shunt protective elements
D series shunt protective elements

(6 × 2) **[12]**

QUESTON 7: ELECTRONIC POWER CONTROL

7.1 One of the main groups into which closed-loop control systems are divided is the follow-up system in which the set point of the system is frequently changed.

Name FOUR subdivisions of the follow-up closed-loop system. (4)

7.2 In manufacturing the CAD system is used to design a project while the CAM system is used to manufacture the project.

Design a schematic representation of the CAD/CAM system, using a fully labelled block diagram. (8)

[12]

QUESTION 8: THYRISTOR DEVICES AND SCR SPEED CONTROL

Draw fully labelled circuit diagrams of each of the TWO methods used to effect resonant commutation. Name the diagrams. **[12]**

QUESTION 9: PROGRAMMABLE LOGIC CONTROLLERS

Define each of the following terms with reference to PLCs:

9.1 Edit

9.2 Element

9.3 Rung

9.4 Address

9.5 Ladder diagram

(5 × 2) **[10]**

TOTAL: 100

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INDUSTRIAL ELECTRONICS N6

FORMULA SHEET

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

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

A = Instantaneous value

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*

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

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

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volts

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

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

hertz

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

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

$$\int^n = Amplification$$ *hertz*

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

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

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

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

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

$$n = t \times f = 1 + \frac{\ln 100}{\int}$$ *number of oscillations*

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

$$°C_{\max} = V_{i\max} \div V / °C$$ *Celsius*

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