higher education
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Department:
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REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N6

(8080186)

22 November 2019 (X-paper)
09:00–12:00

This question paper consists of 6 pages and a formula sheet of 3 pages.

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. Sketches must be large, neat and fully labelled.
5. Write neatly and legibly.

QUESTION 1: TRANSIENTS

1.1 Calculate the time it would take the wave train amplitude of a series RLC circuit to decrease to 1% of its initial peak value if the following data is given.

Logarithmic decrement = 44,44 Natural frequency of oscillation = 32,32 Hz (5)

1.2 If the circuit mentioned in QUESTION 1.1 has an inductor of 12 mH connected to it, calculate the highest value of resistance that would allow oscillations to take place. (6)

[11]

QUESTION 2: TRANSDUCERS

2.1 A voltage-to-current interface network often uses a dropping resistor (R_D).

Briefly describe the function of this resistor and also state how it should be connected in the interface network. (2)

2.2 A process control network must convert a conditioned 1 V–5 V signal, into a standard 4 mA–20 mA current range. Given: $R_F = R_{IN} = 0,75\ k\Omega$.

Calculate the value of the dropping resistor (R_D). (3)

2.3 FIGURE 1 represents a network system used for one of the different interfacing processes.

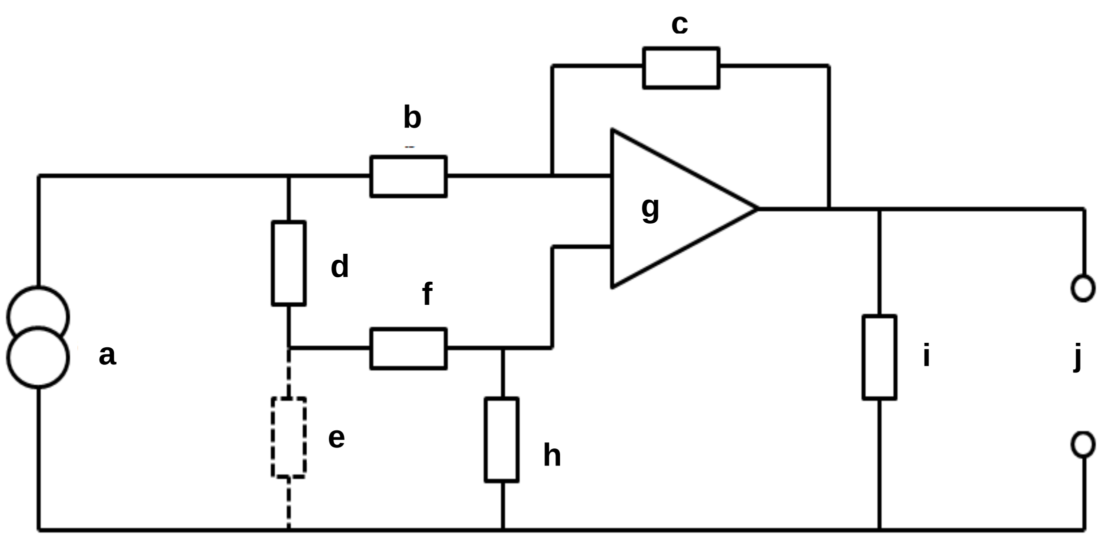

FIGURE 1

2.3.1 Give the full name of the circuit diagram. (1)

2.3.2 Name the parts of the circuit diagram indicated in FIGURE 1 by writing only the answer next to the letter (a-j) in the ANSWER BOOK. (10 × ½) (5)

[11]

QUESTION 3: ULTRASONICS

FIGURE 2 represents a generic diagram of the apparatus used for performing ultrasonic cleaning.

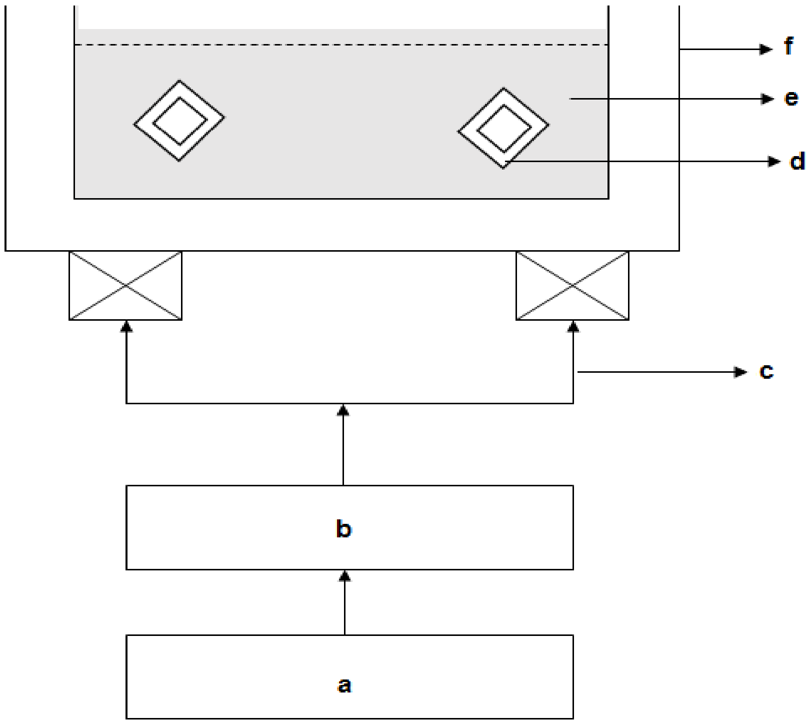

FIGURE 2

3.1 Name the parts indicated in FIGURE 2 by writing only the answer next to the letter (a-f) in the ANSWER BOOK. (6 × 1) (6)

3.2 State FOUR key functions of the slurry, as is used for ultrasonic machining. (4)
[10]

QUESTION 4: X-RAYS AND RADIO ACTIVITY

4.1 In a modern X-ray tube, the power dissipated is 0,9 kW, while the power used is 6,744 kW.

Calculate the total power of the tube. (3)

4.2 Calculate the % efficiency of the X-ray tube mentioned in QUESTION 4.1. (4)

4.3 The current drawn by the X-ray tube mentioned in QUESTION 4.1 is 8 mA.

Calculate the voltage supply needed to operate the tube. (3)

4.4 In terms of physical magnitude and operating voltage, how does the ionisation chamber compare with the semiconductor detector? (2)
[12]

QUESTION 5: AUTOMATIC INSPECTION, TESTING AND NDT

5.1 Choose an item from COLUMN B that matches a description in COLUMN A. Write only the letter (A–E) next to the question number (5.1.1–5.1.5) in the ANSWER BOOK. Each item may be used once only.

COLUMN A		COLUMN B	
5.1.1	Alpha, beta and gamma particles are used to penetrate a specimen to perform NDT.	A	resonance method
5.1.2	This makes use of X-ray sensitive film to perform NDT on a specimen.	B	metal detector
5.1.3	This is used for NDT when the two sides of the specimen being tested are smooth and parallel.	C	hi-go-low system
5.1.4	This prevents damage to machinery and prevents contamination of processed food.	D	radioactive isotopes
5.1.5	This sorts rejected items, after inspection, into waste products and recyclable products.	E	indirect viewing method

(5 × 1) (5)

5.2 FIGURE 3 is a block diagram of a basic metal detector system.

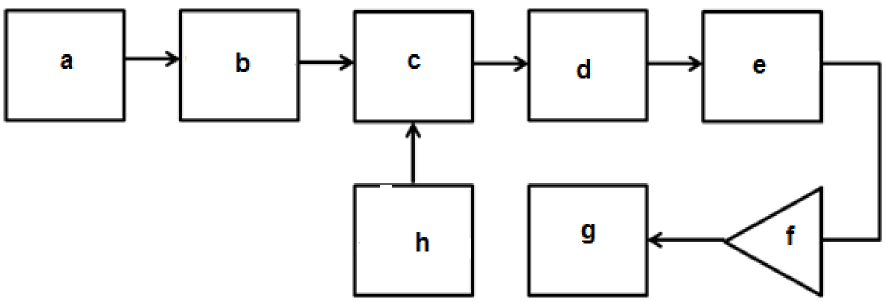

FIGURE 3

Name the parts indicated on the block diagram in FIGURE 3 by writing only the answer next to the letter (a-h) in the ANSWER BOOK. (8 × ½) (4)

5.3 State ONE key advantage of using ultrasonic for NDT. (2)
[11]

QUESTION 6: ELECTRONIC SAFETY DEVICES

6.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'True' or 'False' next to the question number (6.1.1–6.1.5) in the ANSWER BOOK.

6.1.1 The purpose of fitting electronic safety devices in industry is to prevent injury of workers and damage to machinery.

6.1.2 When installing electronic safety devices, the safety device itself does not have to be fail-safe.

6.1.3 Machine operators must be afforded the right to be able to bypass safety devices when operating machines as this, is required by law.

6.1.4 Positive protection is expressed by means of a logical OR function.

6.1.5 Negative protection is expressed by means of a logical AND function.

(5 × 1) (5)

6.2 Draw a neat, labelled circuit diagram of a shunt protective element. (3)

6.3 Give THREE examples of circuit components that can be used as optical receivers. (3)
[11]

QUESTON 7: ELECTRONIC POWER CONTROL

7.1 An open-loop system is characterised by an inability to auto correct.

Draw a labelled block diagram of an open-loop control system. (6)

7.2 Names the TWO main groups into which closed-loop control systems are divided. (2)

7.3 Name in chronological order, the FOUR developmental phases into which the development of a CAD system can be broken down. (4)
[12]

QUESTION 8: THYRISTOR DEVICES AND SCR SPEED CONTROL

8.1 Name THREE methods to effect electrical braking. (3)

8.2 State SEVEN advantages of AC motors used for speed control. (7)

8.3 Name TWO types of AC drives. (2)
[12]

QUESTION 9: PROGRAMMABLE LOGIC CONTROLLERS

Draw a neat, fully labelled block diagram of a functional programmable logic controller. **[10]**

TOTAL: 100

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

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

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*

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

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

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