higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N6

(8080186)

12 April 2021 (X-paper)
09:00–12:00

Nonprogrammable calculators and drawing instruments may be used.

This question paper consists of 7 pages and a formula sheet of 3 pages.

134Q1A2112

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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 question on a new page.
5. Only use a black or blue pen.
6. Write neatly and legibly.

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QUESTION 1: DC TRANSIENTS

1.1 FIGURE 1 shows an RC transient circuit.

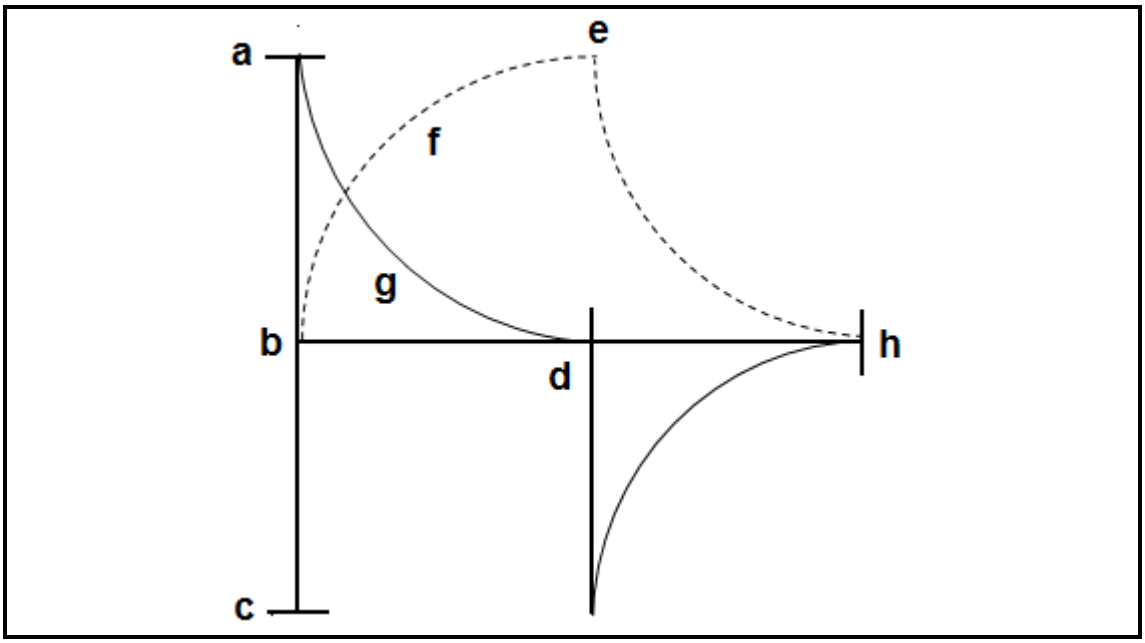


FIGURE 1

1.1.1 Name the cycles between the points b-d and d-h respectively. (2)

1.1.2 Label the points a, c, f and g respectively. (4 × ½) (2)

1.1.3 Briefly explain the transient changes occurring between points a-d and b-e respectively. (2)

1.2 A capacitor of unknown capacitance value is charged to a voltage V_C and then connected in series to a 20 mH inductor.

If a 90-ohm resistor allows maximum oscillations to take place, calculate the value of the capacitor. (5)
[11]

QUESTION 2: TRANSDUCERS

2.1

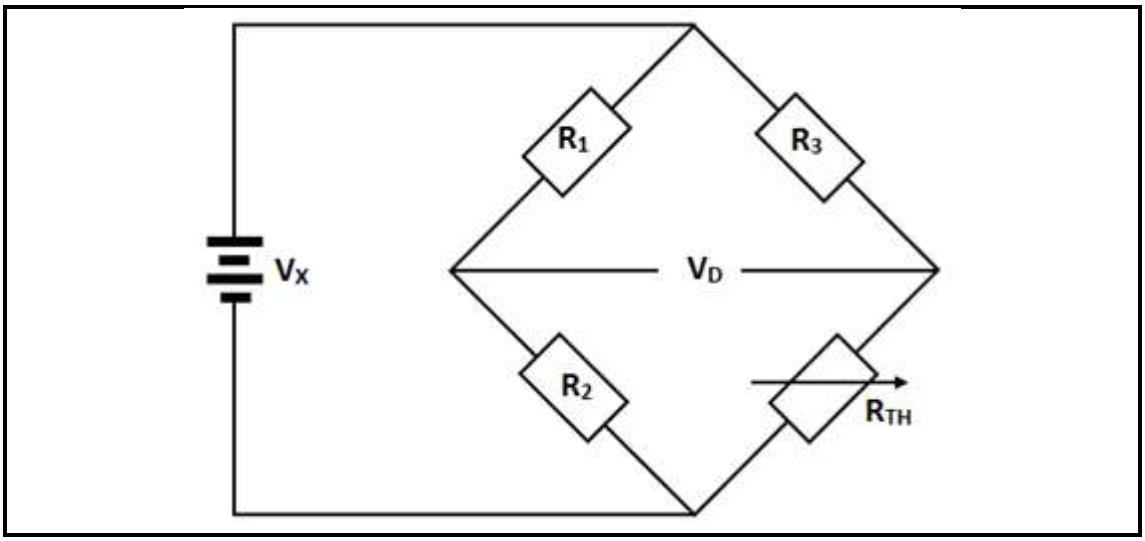


FIGURE 2

Use the data obtained from the bridge circuit shown in FIGURE 2 to calculate the value of the unknown voltage V_X:

$R_1 = R_2 = R_3 = 0,5\ k\Omega$

R_{TH} at 20 °C = 0,5 KΩ (nominal)

ά = 0,001/°C V_D when the temperature at R_{TH} is 100 °C = 57,7 mV (9)

2.2 List the THREE major elements of an electronic instrumentation system. (3)

[12]

QUESTION 3: ULTRASONICS, X-RAYS AND RADIO ACTIVITY

3.1 Give FOUR engineering-related practical applications of ultrasonic energy. (4)

3.2 List FOUR functions of the cutting fluid/slurry used in the applications stated in QUESTION 3.1. (4)

3.3 Choose a term from COLUMN B that matches a description in COLUMN A. Write the letter (A–D) next to the question number (3.3.1–3.3.4) in the ANSWER BOOK.

COLUMN A		COLUMN B	
3.3.1	Energy waves produced by the oscillation or acceleration of an electric charge	A	electromagnetic spectrum
		B	soft X-rays
3.3.2	Range/array of waves of extremely high frequency and short wavelengths to extremely low frequency and long wavelengths	C	electromagnetic radiation
		D	hard X-rays
3.3.3	Electromagnetic waves with longer wavelengths		
3.3.4	Electromagnetic waves with shorter wavelengths		

(4 × 1) (4)

3.4 Draw a neat, labelled circuit diagram of a semiconductor detector. (6)

3.5 Name TWO gas-filled particle detectors. (2)
[20]

QUESTION 4: AUTOMATIC INSPECTION, TESTING AND NDT

4.1 Draw a neat, fully labelled block diagram of a metal detector. (4)

4.2 4.2.1 Explain the operation of a basic metal-detector circuit when no metal is detected within the vicinity of the detector. (4)

4.2.2 Explain the operation of a basic metal-detector circuit when metal is detected within the vicinity of the detector. (5)
[13]

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QUESTION 5: ELECTRONIC SAFETY DEVICES

Choose a term from COLUMN B that matches a description in COLUMN A. Write the letter (A–E) next to the question number (5.1–5.5) in the ANSWER BOOK.

COLUMN A		COLUMN B	
5.1	Protection system applied to an electronic system whereby the operation of the system is dependent on the simultaneous fulfilment of all safety conditions	A	negative protection
5.2	Protection system applied to an electronic system whereby the operation of the system is dependent on the fulfilment of any one of the safety conditions	B	series protection
5.3	Protection system wherein current-limiting resistors are used to restrict the amount of current reaching hazardous areas	C	shunt protection
5.4	Protection system wherein diodes, resistors and capacitors are used ensure the safety of a hazardous area	D	series-shunt protection
5.5	Protection system used to ensure that when the mains supply is applied to zone 2 areas, zone 0 areas are safe	E	positive protection

(5 × 2) **[10]**

QUESTION 6: ELECTRONIC POWER CONTROL

6.1 6.1.1 List THREE characteristics (not operating principles) of a closed-loop control system. (3)

6.1.2 Indicate whether the statements are TRUE or FALSE by writing 'True' or 'False' next to the letter (a–b) in the ANSWER BOOK.

(a) A closed-loop control system employs a feedback mechanism.

(b) A closed-loop system employs reference data for the variable being controlled.

(2 × 1) (2)

6.2 Name the specific type of controller gain for each of the damping types:

6.2.1 Under-damping

6.2.2 Critical damping

6.2.3 Over-damping

(3 × 1) (3)

6.3 Draw a neat, labelled block diagram of a CAD/CAM system. (4)
[12]

QUESTION 7: THYRISTOR DEVICES AND SCR SPEED CONTROL

7.1 Indicate whether the statements are TRUE or FALSE by writing 'True' or 'False' next to the question number (7.1.1–7.1.3) in the ANSWER BOOK.

7.1.1 Uncontrolled rectifier circuits use diodes and capacitors to effect power control.

7.1.2 Fully controlled rectifier circuits use thyristors, diodes and capacitors to effect power control.

7.1.3 Half-controlled rectifier circuits use only thyristors to affect power control.

(3 × 1) (3)

7.2 A thyristor of thermal resistance 1,8 °C/W is mounted on a heat sink with a thermal resistance of 2,0 °C/W.

Calculate the maximum power loss of the thyristor if the junction temperature is not to exceed 125 °C in ambient conditions of 40 °C. (4)

7.3 Give FIVE advantages of using DC motors for speed control with the exception of the wide range of wattage rating. (5)
[12]

QUESTION 8: PROGRAMMABLE LOGIC CONTROLLERS

8.1 Draw a labelled ladder diagram of a logic gate that meets the criteria:

- Two inputs.
- If the two inputs are at the same logic states the output is active.
- If the two inputs are at different logic states the output is inactive. (7)

8.2 Name THREE necessary building blocks of a PLC. (3)
[10]

TOTAL: 100

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FORMULA SHEET

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

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

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-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

$$\int^n = Amplification$$

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

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

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

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

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

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

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

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

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