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NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N6

(8080186)

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09:00–12:00

This question paper consists of 5 pages and 3 formula sheets.

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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 AND TRANSDUCERS

1.1 A 100V, DC Supply is connected to a relay coil with a time constant of 2 milli-seconds. The current in the coil reaches 250mA after 1,5 milliseconds.

Calculate the following:

1.1.1 The maximum value of the current

1.1.2 The resistance and inductance of the coil

1.1.3 The maximum amount of energy stored in the magnetic field (7)

1.2 Name the questions that should be asked before a transducer can be selected. (3)

1.3 Explain what is meant by the term nonlinearity of a transducer and state what can be done to correct it. (4)

1.4 Name THREE typical applications where use is made of offset techniques. (3)

1.5 What exactly is the function of the buffer amplifier, when current-to-voltage interfacing is being used? (3)
[20]

QUESTION 2: ULTRASONICS, X-RAYS AND RADIOACTIVITY

2.1 Give a detailed explanation of ultrasonics. (4)

2.2 Describe the principle of the operation of an ultrasonic soldering iron and state the primary functions of the vibrating tip. (4)

2.3 State THREE factors which determine the efficiency of X-rays. (3)

2.4 2.4.1 List FOUR practical applications of X-rays.

2.4.2 Give ONE example for each application. (4 × 1) (4)
[15]

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QUESTION 3: AUTOMATIC INSPECTION AND TESTING, NDT AND ELECTRONIC SAFETY DEVICES

3.1 Metal detectors are versatile instruments and are increasingly used in various industries to perform a variety of tasks.

3.1.1 Name FOUR industries that use metal detectors.

3.1.2 Briefly state the function of the metal detector in each case.

(2 × 4) (8)

3.2 State THREE advantages of indirect viewing with regard to nondestructive testing. (3)

3.3 Explain the operating principle of indirect viewing with an x-ray tube with reference to nondestructive testing (NDT). (3)

3.4 Calculate a suitable pulse repetition rate for certain steel casting 500 mm thick, having a propagation velocity of 6×10^3 m/s. (4)

[18]

QUESTION 4: SCR POWER SUPPLIES AND ELECTRONIC POWER CONTROL

4.1 Distinguish between open and closed loop process control as applied in the manufacturing process. (4)

4.2 Describe the technique you would employ to positively trigger a thyristor and justify why you would recommend this specific technique. (4)

4.3 Fully explain the following terms with reference to SCR power supplies:

4.3.1 Free-wheel diode

4.3.2 DC line commutation

4.3.3 Pulse-width modulation (PWM)

(3 × 3) (9)

4.4 What are the main benefits of a three-phase thyristor, phase-controller converter in contrast with a single-phase converter? (2)

4.5 Calculate the firing angle of a certain RC phase-shift network having a 10K potentiometer in series with a 0,22 µF capacitor. The circuit is fed from a 380sin377t AC supply. (2)

4.6 Determine the mean load voltage for a $\alpha = 60°$ and a thyristor PIV, should a fully controlled three-phase bridge be supplied with a 311V line voltage. Assume a thyristor volt drop of 1,5V each. (7)

[28]

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QUESTION 5: PROGRAMMABLE LOGIC CONTROLLERS (PLC's)

5.1 Name the items out of which programmable logic controller generally consists. (5)

5.2 Define the following terms with specific reference to PLCs:

5.2.1 Load

5.2.2 Edit

5.2.3 Logic element

5.2.4 Overhead time

5.2.5 Halt

5.2.6 Search

5.2.7 Compare

5.2.8 Address

(8 × 1) (8)

5.3 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (5.3.1–5.3.3) in the ANSWER BOOK.

5.3.1 The CPU of a PLC contains circuitry that performs logical decision-making functions.

5.3.2 Watchdog timers built into the CPU will shut the CPU off, should the scan time exceed a certain predetermined time.

5.3.3 The programmable unit of a PLC always receives the power from the controller unit.

(3 × 2) (6)

[19]

TOTAL: 100

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INDUSTRIAL ELECTRONICS N6

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

A = *Instantaneous value and*

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

B = *Maximum value*

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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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*

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

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

$\int'' = Amplification$ *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*

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

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