higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N6

(8080186)

23 November 2016 (X-Paper)
09:00–12:00

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

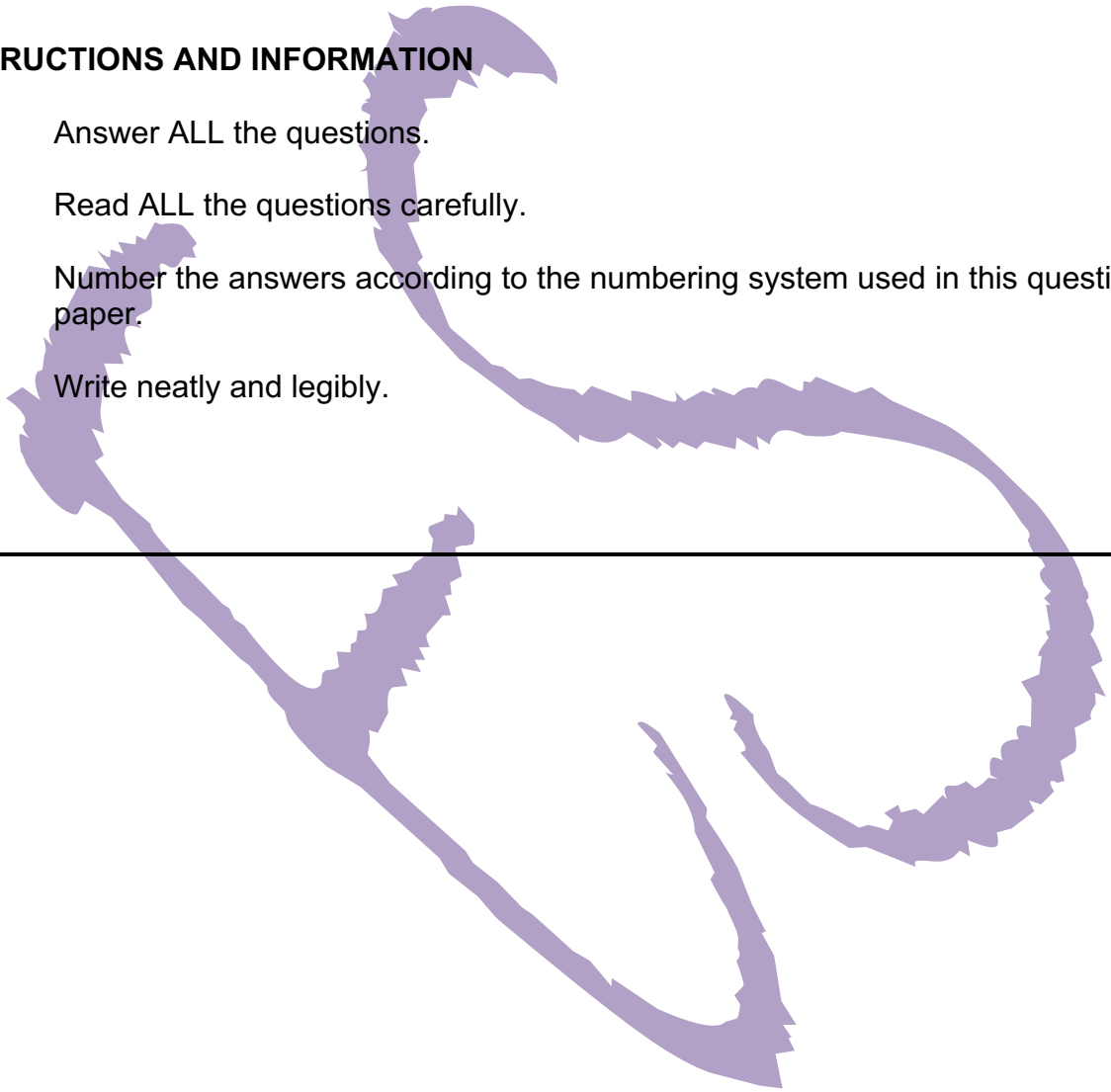
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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

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. Write neatly and legibly.



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QUESTION 1: TRANSIENTS

1.1 The following components are assembled for an experiment on current decay in an R–L–C circuit.

- A variable resistance of unknown value
- A capacitor of 22,75 µF
- An inductor of 32,25 mH

If critical damping is employed for this experiment, calculate the value of the natural frequency (fn) of oscillation of the wave train that would be produced on the display of the test instrument used for this experiment. (10)

1.2 Name the other TWO damping methods that could also be used to conduct the experiment in QUESTION 1.1 above. (2)
[12]

QUESTION 2: TRANSDUCERS

2.1 Give the standard current range values that must be used for signal conditioning. (1)

2.2 In a face brick manufacturing factory, the temperature of a thermally insulated chamber ranges from 155 °C to 555 °C. A thermocouple which measures 1,55 mV per 10 °C on the output of an Op-Amp multiplier circuit is used to interface with a standard signal range of 1 V to 5 V for a metering resistor value 1,55 KΩ.

Calculate the value of the suitable feedback resistor that is connected to the Op-Amp. (9)
[10]

QUESTION 3: ULTRASONICS, X – RAYS AND RADIO ACTIVITY

3.1 Ultrasonic energy is generated through waves that have short wavelengths.

State TWO characteristic features of ultrasonic energy as a result of the short wavelengths. (2)

3.2 When employing ultrasonic machining processes to machine hard and brittle materials, it is the cutting fluid and not the cutting tool that does the actual cutting.

3.2.1 Give another name for the cutting fluid that is used for ultrasonic machining process. (1)

3.2.2 State FOUR functions of the cutting fluid used during the ultrasonic machining process. (4)

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3.3 State the main advantage for not generating external heat when employing ultrasonic welding techniques. (1)

3.4 A photomultiplier tube has a cathode sensitivity of 45 µA per lumen and consists of 6 stages each with an emission factor of 7. If the maximum safe output current may not exceed 5,5 mA, then

Calculate the following:

3.4.1 The amplification (2)

3.4.2 The tube sensitivity (2)

3.4.3 The maximum safe illumination (3)

3.5 Name the THREE factors that determine the sensitivity of a photomultiplier. (3)
[18]

QUESTION 4: AUTOMATIC INSPECTION, TESTING AND NDT

4.1 Inspection of articles forms an integral part in any manufacturing process.

4.1.1 Give ONE main reason for the need to carry out the inspection process on manufactured articles. (1)

4.1.2 Name the TWO groups into which inspection, testing, sorting and grading devices are divided. (2)

4.1.3 Distinguish, in terms of yielded results, between the TWO inspections systems in QUESTION 4.1.2 above. (4)

4.2 Non-Destructive Testing is a method used for testing items for defects which are not visible to the human eye. This can be achieved through the use of X-ray tubes.

Name the THREE methods commonly used for Non- Destructive Testing through the use of X-ray tubes. (3)
[10]

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QUESTION 5: ELECTRONIC SAFETY DEVICES AND ELECTRONIC POWER CONTROL

5.1 In industry, safe operation of machines is dependent upon acute designs and connections of electronic safety devices to the industrial machine.

Distinguish, with respect to connection techniques, THREE main differences between *positive protection* and *negative protection.* (3 × 2) (6)

5.2 Briefly define the term intrinsic *safety*, as applicable to the workplace safety environment. (3)

5.3 Closed-loop control systems are divided into two main groups.

Name and describe the TWO groups into which closed-loop control systems are divided. (4)

5.4 The development of a CAD system can be broken down into a number of development stages.

Draw a labelled block diagram to show these stages. (6)
[19]

QUESTION 6: THYRISTOR DEVICES AND SCR SPEED CONTROL

6.1 A simple thyristor half-wave rectifier circuit which uses an SCR and a resistive load, operates on the following data:

- V_{SUPPLY} = 240 V RMS
- R_L = unkown value
- Thyristor (SCR) Current = 15 A

Calculate the following:

6.1.1 The mean load voltage for 0° and 90° (3 × 2) (6)

6.1.2 The maximum thyristor voltage (2)

6.1.3 The RMS value of the current flowing through the thyristor. (2)

6.2 State SIX advantages of direct-current motor-speed control. (6)
[16]

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QUESTION 7: PROGRAMMABLE LOGIC CONTROLLERS

7.1 A typical PLC consists of three basic sections, namely, a programmer, a programmable controller and an expansion unit.

Draw a complete, fully labeled block diagram of a programmable controller unit of a PLC. (7)

7.2 Define the following terms as used in the study of PLC's:

7.2.1 Edit

7.2.2 Element

7.2.3 Rung

7.2.4 Timer

(4 × 1) (4)

7.3 Draw a labeled ladder diagram of a NAND function using two input contacts. (4)

[15]

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*

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

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

$\int^n$ = *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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