higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T1140(E)(N17)T
NOVEMBER 2010

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N6

(8080186)

17 November (X-Paper)
09:00 – 12:00

This question paper consists of 5 pages and a 3-page formula sheet.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
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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 correctly according to the numbering system used in this question paper.
4. ALL the steps of calculations must be shown.
5. Label ALL circuit diagrams.
6. Rule off across the page on completion of each question.
7. Write neatly and legibly.

QUESTION 1: TRANSIENTS AND TRANSDUCERS

1.1 A 200 volt DC supply is connected to a relay coil with a time constant of 3 milliseconds. If the current in the coil reaches 0,3 A after 2 milliseconds, determine the final current value and the resistance and inductance of the coil. (6)

1.2 Should a 22 µF capacitor be charged to a voltage V_c and then connected across a 30 mH inductor which has a maximum resistance value of 89 Ω, it is found that the natural frequency of oscillation is 45 Hz.

Calculate the following:

1.2.1 The logarithmic decrement (3)

1.2.2 The time taken for the wave train amplitude to decrease to 1% of its initial value (4)

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1.3 Combining analog signals may be achieved by using multiple inputs to an op-amp. Indicate, by means of a suitable diagram with associated output formulas, how series addition and subtraction can be obtained by using TWO inputs to the op-amp. (6)

1.4 Determine the value of the second input voltage (V_2) for a summing amplifier consisting of 3 inputs with V_1 and V_3 being 1 V and 3 V respectively. The circuit employs a 1 000 kΩ feedback resistor with input resistors R_1, R_2 and R_3 having values of 500 kΩ, 1 000 kΩ and 1 MΩ respectively and (V_0) = –7 V. (5)

[24]

QUESTION 2: ULTRASONICS, X-RAYS AND RADIO-ACTIVITY

2.1 Give a detailed explanation of *ultrasonics*. (4)

2.2 The cathode of a certain X-ray tube is emitting $1{,}5 \times 10^{17}$ electrons per second. The tube has an anode voltage of 150 kV and the target material has an atomic number of 42.

Calculate the following:

2.2.1 The shortest wavelength of X-rays produced (3)
2.2.2 The percentage efficiency (2)
2.2.3 The power dissipated by the tube (6)

2.3 Discuss the following terms regarding radio-activity with specific reference to change and penetration abilities:

2.3.1 Alpha radiation (2)
2.3.2 Beta radiation (2)
2.3.3 Gamma radiation (2)

2.4 Give a labelled sketch as well as a brief description of the operating principle of a Geiger-Müller counter used for the detection of radiation. (6)

[27]

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

3.1 Define *intrinsic safety.* (3)

3.2 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (3.2.1 – 3.2.5) in the ANSWER BOOK. Correct any statement which, in your opinion, is FALSE.

3.2.1 Sonar method is used in thickness gauging using the principle whereby the signal is reflected from an interface.

3.2.2 Opto-electronics refers to electronic circuits having at least one feedback using an electrical signal.

3.2.3 It is the fundamental of intrinsic safety that energy is kept at a low level only under abnormal conditions.

3.2.4 When determining whether a certain instrument is intrinsically safe, the construction review procedure involves the assurance of a margin of safety under the worst possible conditions.

3.2.5 The insulation test prescribed for an intrinsically safe transformer is that such a transformer must pass a one minute insulation test at 1 000 V plus twice the rated voltage, after a burnout test. (7)

3.3 Illustrate, by means of a labelled diagram, how series-shunt elements are used in the Zener barrier technique to ensure that the current reaching the hazardous area is safe. (5)

[15]

QUESTION 4: SCR POWER SUPPLIES AND ELECTRONIC POWER CONTROL

4.1 Closed-loop control systems can be divided into two main groups. Name the TWO groups and briefly explain the difference between them with the aid of practical examples. (6)

4.2 State FOUR advantages of DC motor speed control. (4)

4.3 Calculate the mean output voltage for an uncontrolled three-phase bridge rectifier operating from 120 volt per phase supply. (3)

4.4 Name and briefly discuss the prerequisites for a computer-aided manufacture (CAM) system. (8)

[21]

QUESTION 5: PROGRAMMABLE LOGIC CONTROLLERS (PLC's)

5.1 Draw a labelled block diagram of a programmable logic controller (PLC). (9)

5.2 State any FOUR practical applications using PLC's. (4)
[13]

TOTAL: 100

$A = B \cdot \left(1 - e^{-t/\tau}\right)$ | A = *Instantaneous value and*

$A = B \cdot e^{-t/\tau}$ | B = *Maximum value*

$V = E \cdot \left(1 - 2e^{-t/\tau}\right) = I \cdot R$ *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
$\Delta R = R_{TH} \times \Delta t \times temperature\ coefficient$	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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