higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N6

(8080186)

5 April 2018 (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 An initially de-energised inductor of 24 mH is connected in series to a 20 Ω resistor. The two are then connected across a 50 V DC supply.

Calculate the following:

1.1.1 The current flowing 0,5 ms after switch on. (4)

1.1.2 The time taken for the voltage across the resistor to equal the voltage across the inductor. (5)

1.2 When constructing basic electronic circuits, use is made of both, passive and active components. Tabulate each of the following electronic circuit components into either active or passive.

- Transistor
- Diode
- I.Cs
- Resistor
- Capacitor
- Inductor

(3)
[12]

QUESTION 2: TRANSDUCERS

2.1 The output signal from a transducer needs to be modified, before being used to actuate a second system. This modification process is termed signal conditioning.

2.1.1 Name TWO common electronic components that are used to perform signal conditioning. (2)

2.1.2 Signal amplification is one of the examples of the signal conditioning process.

List FIVE other typical examples of the signal conditioning process. (5)

2.2 Draw a neat, labelled, circuit diagram of a typical detector bridge network, which can be used in conjunction with an Op-Amp during signal conditioning processes. (3)
[10]

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QUESTION 3: ULTRASONICS, X-RAYS AND RADIO ACTIVITY

3.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (3.1.1–3.1.4) in the ANSWER BOOK.

3.1.1 Ultrasonic energy is acoustic energy at frequencies below the audible range of sound which has a limit of 20 KHz.

3.1.2 The piezo-electric effect only refers to non-conductive materials.

3.1.3 Magnetostriction only refers to conductive materials.

3.1.4 Propagation properties of ultrasonic energy through a vacuum are excellent.

(4 × 1) (4)

3.2 Radioactive materials are said to have severe biological effects, when coming into contact with human living tissue.

Name the FOUR factors upon which the injury that could be caused by interaction with radioactive materials is dependent on. (4)

3.3 A photomultiplier tube has a cathode sensitivity of 10 µA per lumen and consists of 4 stages, each with an emission factor of 2. The maximum safe output current may not exceed 1 mA.

Calculate the following:

3.3.1 The amplification (2)

3.3.2 The tube sensitivity (2)

3.3.3 The maximum safe illumination (3)

[15]

QUESTION 4: AUTOMATIC INSPECTION, TESTING AND NDT

4.1 Mention ONE advantage of the direct-viewing method, as used for non-destructive testing. (1)

4.2 Mention THREE advantages of the indirect viewing method as is used for NDT. (3)

4.3 During manufacturing, an automatic inspection system ensures conformity to specifications by means of electronic circuitry for manufactured products.

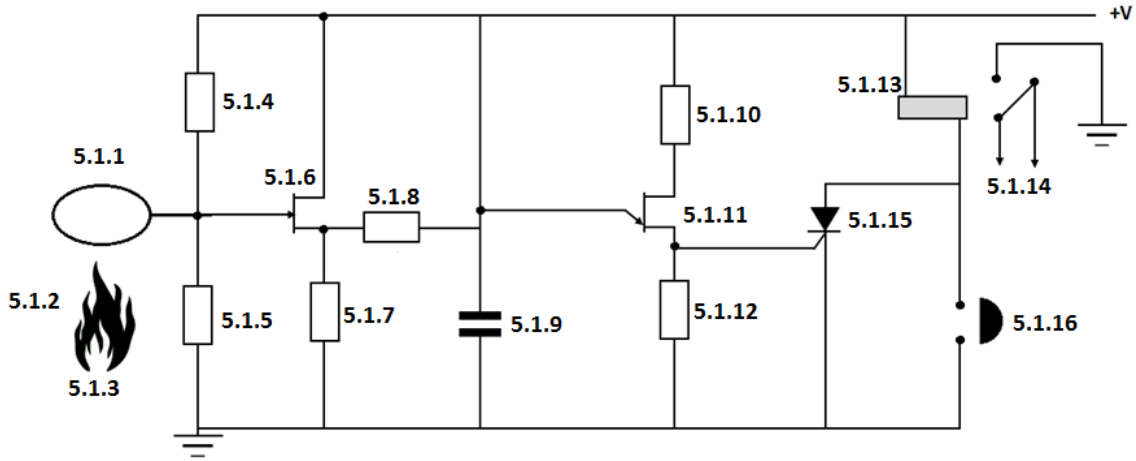
Draw a neat, labelled generic block diagram of an automatic inspection, testing and grading system. (6)

[10]

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QUESTION 5: ELECTRONIC SAFETY DEVICES AND ELECTRONIC POWER CONTROL

5.1 The circuit below depicts a flame failure detection, safety device for the safe operation of an industrial furnace. Label the parts (5.1.1–5.1.16) in the ANSWER BOOK. (Do NOT redraw the diagram)



(16 ×½) (8)

5.2 In point form, describe the basic operation of the circuit in QUESTION 5.1 above, under circumstances whereby the flame suddenly extinguishes. (3)

5.3 An office-orientated uninterruptible power supply (UPS) system is one that contains high performance electromagnetic and radio frequency interference circuitry to protect computer equipment from damage, should a sudden power failure occur.

Set up a labelled block diagram of a UPS system suitable for office/domestic use. (12)

[23]

QUESTION 6: THYRISTOR DEVICES AND SCR SPEED CONTROL

6.1 A thyristor with a thermal resistance of 0,9 °C/W is mounted on a heat sink with a thermal resistance of 1,0 °C/W.

Calculate the maximum power loss of the thyristor if the junction temperature is not to exceed 125 °C in ambient temperature conditions of 20 °C. (4)

6.2 A certain thyristor experiences a surge that gives a power loss of 2 KW for 10 ms, during switch-on from cold conditions of 40 °C.

Calculate the junction temperature if the transient thermal impedance for this time is 0.03 °C/W. (4)

6.3 Name TWO types of resonant commutation. (2)

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6.4 Name the THREE categories of rectifier circuits. (3)

6.5 Give ONE type of a cyclo-converter, and ONE type of an inverter, as are used for frequency conversion. (2)
[15]

QUESTION 7: PROGRAMMABLE LOGIC CONTROLLERS

7.1 Set up a complete fully labelled block diagram of a programmable logic controller (PLC). (5)

7.2 Design, using ladder diagram logic, a program that will execute the following instructions for a two-way alarm system:

- The first sound of the alarm should ring for 30 seconds when the start button is activated, and then it should stop.
- 120 seconds later, the second sound of the alarm should ring for 30 seconds, and then stop.
- 120 seconds later, the first sound should start ringing again for 30 seconds, and then stop.
- The cycle should repeat until the stop button on the PLC is activated.

HINT

Use the following:

- NO Contacts
- NC Contacts
- Timers
- Output Coils
- End Statements (10)
[15]

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*

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

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$V_{\max} = \sqrt{2} \times V_{line} = \sqrt{2} \times V_{rms}$ *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*

$I_{max} = Maximum\ safe\ illuminati\ on\ \times Tube\ sensitivity$ *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*

$\int^n = Amplificat\ ion$ *hertz*

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

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