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education

Department:
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NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N6

(8080186)

31 March (X-Paper)
09:00 – 12:00

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

DEPARTMENT OF EDUCATION
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 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 circuit consists of a 4 ohms resistor in series with a 2 henry inductance. When a step voltage of 20 volts is applied, determine:

1.1.1 The instantaneous current after 0,5 seconds (4)

1.1.2 The voltage developed across the resistor after 2 seconds (2)

1.1.3 The maximum energy stored in the magnetic field (2)

1.2 Explain fully, with the aid of suitable sketches, what is meant by under damping, over damping and critical damping of an RLC circuit. State the conditions applicable in each case with specific reference to the formula of calculating natural frequency of oscillations. (9)

1.3 The transducer is an important input element when transforming a physical quantity into a proportional electrical signal. Name THREE elementary questions to be asked before a transducer is selected for a specific application. (3)

1.4 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (1.4.1 – 1.4.3) in the ANSWER BOOK.

1.4.1 The operational amplifier is a very high-gain differential amplifier employing current feedback to provide a stabilized gain.

1.4.2 The thermocouple is an example of an active transducer.

1.4.3 Interface circuits may be categorized as either driver or receiver units. (3 × 1) (3)

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

2.1 Explain why you would select an ultrasonic drilling machine rather than a conventional drilling machine for a particular job. (3)

2.2 Explain, with the aid of sketches, how x-rays are produced when a high velocity electron beam hits the atomic structure of the target material. (6)

2.3 Explain the principle of operation of a modern x-ray tube and enhance your description with a suitable sketch. (6)

2.4 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (2.4.1 – 2.4.6) in the ANSWER BOOK. Correct any statement which, in your opinion, is incorrect.

2.4.1 The quartz crystal is commonly used in the piezo-electric effect.

2.4.2 Attenuation of ultrasonic energy takes place when the energy is propagated over a distance. This attenuation is directly proportional to the density of the material and indirectly proportional to the square of the distance travelled.

2.4.3 The direct piezo-electric effect refers to the change in the dimensions of a crystal when the crystal is subjected to an alternating EMF or magnetic field.

2.4.4 The longer the wavelength of the x-ray, the greater is its energy and its penetrating power.

2.4.5 When the gas-filled ionization chamber detector is compared with the semiconductor detector, it is found that the ionisation chamber detector is much smaller and its operating voltage is also lower than that of the semiconductor detector.

2.4.6 The photomultiplier tube makes use of secondary emission to provide current amplification. (10)

[25]

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

3.1 What is the purpose of fitting electronic safety devices to operating machines in an industry? (2)

3.2 Name the main components of an optical relay. (3)

3.3 Distinguish between positive and negative feedback and enhance your explanation with a practical example in each case. (4)

3.4 Illustrate, by means of a labelled diagram, how current-limiting resistors are used in series protection to restrict the amount of current reaching the hazardous areas in intrinsically safe equipment. (4)

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QUESTION 4: SCR POWER SUPPLIES AND ELECTRONIC POWER CONTROL

4.1 Explain, with the aid of a labelled block diagram and a brief description, what is meant by open-loop control, as applied to electronic power control. (5)

4.2 Draw a fully labelled block diagram of a typical CAD/CAM system. (4)

4.3 Draw a practical circuit diagram of parallel-capacitance (DC Chopper) commutation and give a detailed description of its operating principle. (7)

4.4 A single-phase controlled half-wave rectifier is fed from a 240 V, 50 Hz supply.

Calculate the following:

4.4.1 The load voltage for $\alpha = 45°$ (2)

4.4.2 A suitable PIV rating for the thyristor (1)

4.5 4.5.1 Calculate the firing angle of a certain RC phase-shift network having a 10 K potentiometer in series with a 0,22 μF capacitor. The circuit is fed from 380 sin 377 t AC supply. (2)

4.5.2 What is the input frequency of the AC supply in QUESTION 4.5.1? (1)

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QUESTION 5: PROGRAMMABLE LOGIC CONTROLLERS (PLC's)

5.1 What do the following abbreviations stand for with specific reference to PLC's?

5.1.1 CMOSRAM (2)
5.1.2 EEPROM (2)
5.1.3 I/O (2)

5.2 Briefly explain the procedure that follows when data enters the PLC till the data is provided to output devices. (4)

5.3 Draw a labelled ladder diagram that will energize the output coil when the input is activated momentarily. Should the input however, be activated for a period exceeding 10 seconds, the output coil must be de-energized.

Use only the following elements:

- Normally closed contacts
- Normally open contacts
- Timers
- Output coils
- END statements

(7)

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TOTAL: 100

INDUSTRIAL ELECTRONICS N6

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$V_{line} = \sqrt{3} \times V_{per\ phase}$ *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*

$I_{tube} = \text{Number of electrons per second} \times q$ *amps*

$I_{max} = \text{Maximum safe illumination} \times \text{Tube sensitivity}$ *amps*

$\text{Sensitivity} = \text{Cathode sensitivity} \times A$ *amps/lumen*

$P = I^2 \cdot R = V \cdot I = V^2 / R$ *watts*

$\text{X-ray power} = P_T \times \eta$ *watts*

$\text{Dissipated power} = P_T - \text{Power used}$ *watts*

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

$Z_{TH} = \frac{T_{rise}}{T_{loss}}$ *ohms*

$R = \frac{T_1 - T_2}{P} = \frac{L}{\tau}$ *ohms*

$f = \frac{I}{t} = \frac{c}{\lambda} = \frac{\omega}{h} = \frac{\omega}{2\pi} = \frac{E \times q}{h}$ *hertz*

$f_r = \frac{1}{2\pi \times \sqrt{LC}}$ *hertz*

PTO

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

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