higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N3

(8080613)

22 November 2023 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

This question paper consists of 9 pages and 1 formula sheet.

044Q1E2322

Copyright reserved

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
INDUSTRIAL ELECTRONICS N3
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer all the questions in SECTION A.
2. Answer all the questions in SECTION B.
3. Start each section on a new page.
4. Read all the questions carefully.
5. Number the answers according to the numbering system used in this question paper.
6. Answers to calculations must be given correctly to THREE decimal places after the comma.
7. All calculation must have the following three steps:
   1: The formula
   2: The replacement of values
   3: The answer and correct SI-unit
8. Use only blue or black pen, and sketches must be drawn neatly and with pencil.
9. Write neatly and legibly.

Copyright reserved

SECTION A

QUESTION 1

1.1 Various options are given as possible answers to the following questions. Choose the correct answer and write only the letter (A–D) next to the question number (1.1.1–1.1.5) in the ANSWER BOOK.

1.1.1 The op-amp can amplify …

A AC signals only.
B DC signals only.
C both AC and DC signals.
D neither DC nor AC signals.

1.1.2 In an unregulated power supply, if input AC voltage increases, the output voltage …

A increases.
B decreases.
C remains the same.
D None of the above

1.1.3 The … of a circuit describes the ability of that circuit to respond to certain frequencies while rejecting all others.

A bandwidth
B selectivity
C sensitivity
D quality factor

1.1.4 At frequencies well above and below the resonant frequency, the series RLC circuit looks …

A like a short.
B like an open.
C inductive.
D capacitive.

1.1.5 In the normal operation of an SCR, anode is … with regard to the cathode.

A at zero potential
B negative
C positive
D None of the above

(5 × 1) (5)

1.2 Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (1.2.1–1.2.5) in the ANSWER BOOK.

1.2.1 A semiconductor is a material that is neither a good conductor nor a good insulator.

1.2.2 The resonant frequency of the circuit in FIGURE 1 is 1583 Hz

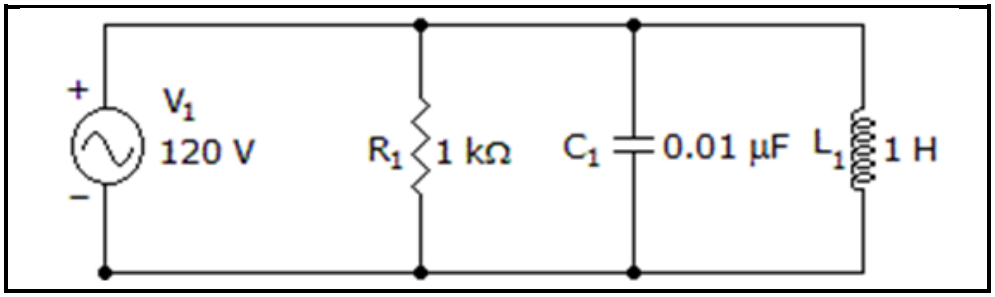


FIGURE 1

1.2.3 A silicon-controlled rectifier (SCR) has three terminals labelled base, collector and emitter.

1.2.4 The condition of a semiconductor diode cannot be determined with an ohmmeter.

1.2.5 A common-emitter amplifier is so called because the emitter is connected to both the input and output signals.

(5 × 1) (5)

1.3 Give ONE word/term for each of the following descriptions by choosing a word/term from the list below. Write only the word/term next to the question number (1.3.1–1.3.5) in the ANSWER BOOK.

maximum; Class B; convert energy; surge current; transient; minimum; Class A; leakage current; critical voltage; transmit electrical energy

1.3.1 The maximum allowable current that can flow through a diode for a specific time and not damage the diode.

1.3.2 When parallel resonance occurs the current in the circuit will be … .

1.3.3 In this class of amplifier, the bias point is at the cut-off region.

1.3.4 A sudden change in current or voltage that goes outside the user tolerance limits and returns to and remains within these limits within a specified recovery time (longer than 1 m/s) after the initiation of the disturbance.

1.3.5 What is a transducer's function?

(5 × 1) (5)

Copyright reserved

1.4 Choose a/an word/item from COLUMN B that matches a description in COLUMN A. Write only the letter (A–J) next to the question number (1.4.1–1.4.5) in the ANSWER BOOK.

COLUMN A		COLUMN B	
1.4.1	Current that will flow when the diode is connected in reverse bias	A	closer to the valence band
		B	leakage current
1.4.2	Control is achieved by controlling the time at which the gate of the SCR is triggered	C	voltage
		D	surge current
1.4.3	Cathode ray oscilloscope displays graph of waveforms based on	E	resolution
		F	current
1.4.4	The fermi level for a P-type material is …	G	phase control
		H	cycle control
1.4.5	The smallest change in the measured value that a measuring instrument will respond to	I	closer to the conduction band
		J	precision

(5 × 1) (5)
[20]

TOTAL SECTION A: 20

SECTION B

QUESTION 2: DC THEORY AND AC THEORY

2.1 FIGURE 2 below shows a serie-parallel DC circuit.

By making use of Kirchhoff's current and voltage laws calculate the unknown currents I_1 and I_2.

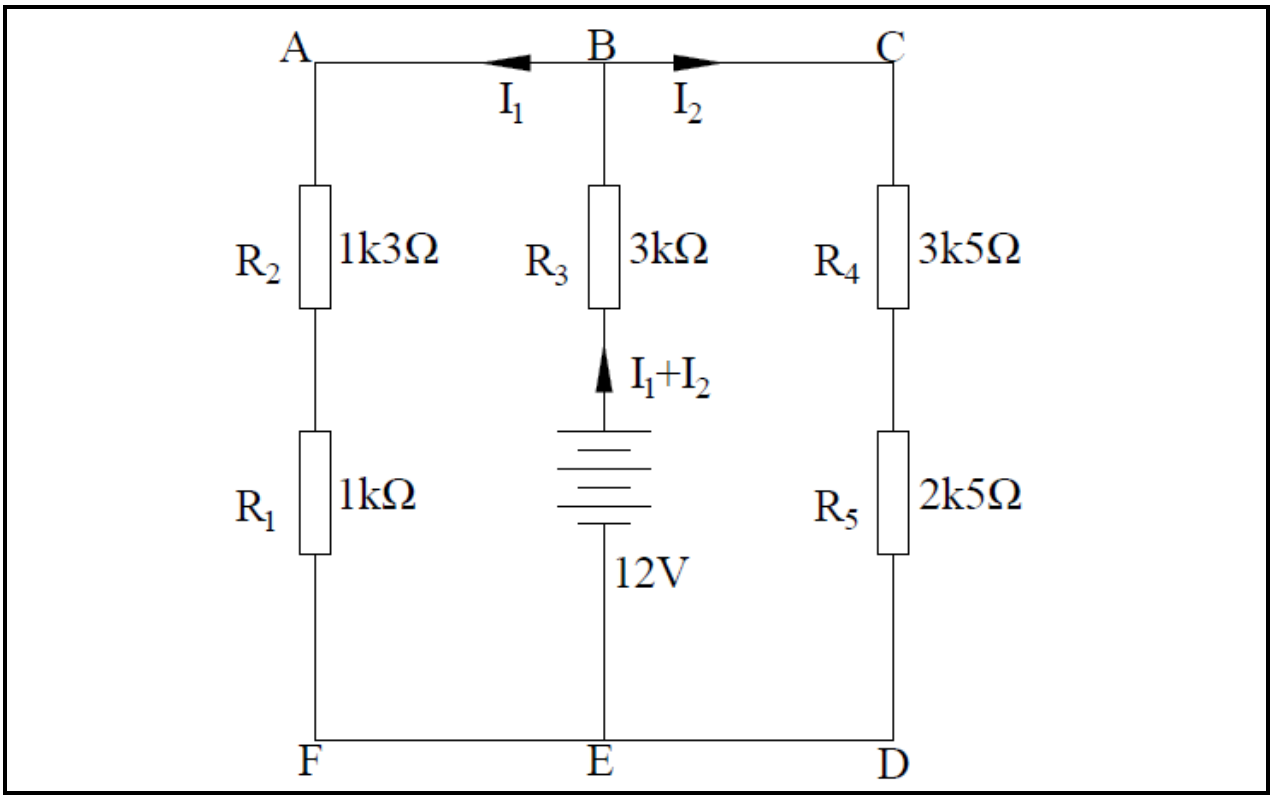


FIGURE 2 (10)

2.2 Three branches of a parallel RCL circuit have the following components: a resistor with a value of 50 Ω in the first branch; a capacitor of 100 µF in the second branch and an inductor with a value of 0,15 H in the third branch. The circuit is then connected across a 220 V / 50 Hz power supply.

Calculate the following:

2.2.1 The inductive and capacitive reactance. (4)

2.2.2 The current flow in each branch. (5)

2.2.3 The total current. (2)

2.2.4 The phase angle between the total current and total voltage. (2)

[23]

QUESTION 3: SEMI-CONDUCTOR DIODES AND TRANSDUCERS

3.1 Fermi levels are a convenient way of showing the relative distribution of charge carriers.

Answer the following questions regarding Fermi levels.

3.1.1 Draw a neat, labelled drawing depicting the Fermi level of a P–type of material. (2)

3.1.2 Draw a neat, labelled drawing depicting the Fermi level of a PN–junction. (2)

3.2 The Diode Clipper, also known as a Diode Limiter, is a wave shaping circuit that takes an input waveform and clips or cuts off its top half, bottom half.

Answer the following questions regarding clipper circuits:

3.2.1 Draw a neat, labelled circuit diagram of a negative parallel clipper.

3.2.2 Draw the input and output waveforms for a positive series clipper. (2 × 2) (4)

3.3 A Zener diode is a heavily doped semiconductor device that is designed to operate in the reverse direction.

Draw a neat labelled characteristic curve for the Zener diode. (3)

3.4 A light emitting diode (LED), is a specialised type of diode as it has very similar electrical characteristics to a PN junction diode.

Explain in your own words the operating principle of a LED. (2)

3.5 A capacitive transducer is a type of transducer or sensor that works on the principle of change in capacitance.

Explain the operating principle of a capacitive transducer (2)

3.6 The definition of a piezoelectric transducer is an electrical transducer that can convert any form of physical quantity into an electrical signal.

Answer the questions below:

3.6.1 Draw a neat, labelled drawing showing the construction of a piezoelectric transducer. (3)

3.6.2 Name TWO areas of application of a piezoelectric transducer. (2)

[20]

QUESTION 4: SEMI-CONDUCTOR TRANSISTORS AND OPERATIONAL AMPLIFIERS

4.1 Transistor switches can be used to switch and control lamps, relays or even motors.

Draw a neat, labelled circuit diagram where a transistor is used to switch off a lamp when light will fall on a photo diode. (4)

4.2 Coupling in transistor amplifiers means the method of connecting multiple stages of amplifiers.

Draw a neat, labelled circuit diagram of two common emitter amplifiers connected using the RC coupling method. (4)

4.3 The common emitter amplifier is a basic single-stage bipolar junction transistor and is used as a voltage amplifier.

Draw a neat, labelled graphical representation of the input and output of a Class AB amplifier. (3)

4.4 A transistor acts as an amplifier by raising the strength of a weak signal.

By comparing a common collector amplifier and a common base amplifier discuss the differences between the two amplifiers under the following headings:

4.4.1 Phase shift (1)

4.4.2 Voltage gain (2)

4.5 An operational amplifier is an integrated circuit that can amplify weak electric signals.

Answer the questions that follow:

4.5.1 Draw a neat, labelled circuit diagram of an op-amp when used as an audio amplifier. (3)

4.5.2 Draw a neat, labelled circuit diagram of a non-inverting op-amp. (2)

[19]

Copyright reserved

QUESTION 5: MEASURING INSTRUMENTS AND ELECTRONIC POWER CONTROL

5.1 Errors that occur during measurement are known as measurement errors.

Systematic errors can be divided in two categories, namely instrumental and environmental errors. Differentiate between *instrumental* and *environmental errors*. (2)

5.2 The function of the cathode-ray tube (CRT) is to convert an electrical signal into a visual display.

Explain in your own words the basic operation of the CRT. (3)

5.3 Digital voltmeter (DVM) is an instrument used to measure the electrical potential difference between two points in a circuit.

By referring to continuous balance DVMs answer the following questions:

Draw a neat, labelled block diagram of a continuous balance DVM. (6)

5.4 By making use of two transistors, draw a circuit diagram and explain the working principle of the silicon controlled rectifier (SCR). (4)

5.5 Draw a neat, labelled circuit diagram of a half-wave control circuit of the SCR. (3)

[18]

TOTAL SECTION B: 80
GRAND TOTAL: 100

Copyright reserved

INDUSTRIAL ELECTRONICS N3

FORMULA SHEET

Direct-current theory

$V = I \cdot R$ $\quad P = V \cdot I$ $\quad P = \dfrac{V^2}{R}$

$P = I^2 \cdot R$

Alternating-current theory

$X_L = 2\pi fL$ $\quad X_C = \dfrac{1}{2\pi fC}$ $\quad Z = \sqrt{R^2 + (X_L \sim X_C)^2}$

$V_T = \sqrt{V_R^2 + (V_L \sim V_C)^2}$ $\quad I = \dfrac{V_T}{Z}$ $\quad \theta = \cos^{-1}\dfrac{R}{Z}$

$V = I \cdot R$ $\quad V = I \cdot X_L$ $\quad V = I \cdot X_C$

$f_r = \dfrac{1}{2\pi\sqrt{LC}}$ $\quad I_R = \dfrac{V_T}{R}$ $\quad I_L = \dfrac{V_T}{X_L}$

$I_C = \dfrac{V_T}{X_C}$ $\quad I_T = \sqrt{I_R^2 + I_X^2}$ $\quad I_X = I_L \sim I_C$

$\theta = \tan^{-1}\dfrac{I_X}{I_R}$ $\quad \theta = \cos^{-1}\dfrac{I_R}{I_T}$ $\quad Z = \dfrac{V}{I_T}$

$Z_D = \dfrac{L}{RC}$ $\quad I_T = \dfrac{V}{Z_D}$ $\quad f_r = \dfrac{1}{2\pi}\sqrt{\dfrac{1}{LC} - \dfrac{R^2}{L^2}}$

$I_C = I_{RL}\ Sin\theta_L$ $\quad I_T = I_{RL}\ Cos\theta_L$ $\quad I_T = \sqrt{{I_{T_H}}^2 + {I_{T_V}}^2}$

Transistors

$I_C = \dfrac{V_{CC}}{R_L}$

Transducers

$R = \dfrac{\rho \cdot l}{a}$ $\quad C = \dfrac{k \cdot A \cdot E_o}{d}$

Copyright reserved