higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N3

(8080613)

16 November 2022 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

This question paper consists of 10 pages and 1 formula sheet.

048Q1E2216

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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.
2. Read all the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Start each section on a new page.
5. Round off answers correctly to THREE decimal places.
6. All calculations must have the following three steps:
   - 6.1 The formula
   - 6.2 The replacement of values
   - 6.3 The answer and correct SI unit
7. Use a black or blue pen for written answers and a pencil for sketches.
8. Write neatly and legibly.

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SECTION A

QUESTION 1

1.1 Various options are given as possible answers to the following questions. Choose the 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 If an element has exactly eight electrons it can be classified as a/an …

A resistor.
B conductor.
C semiconductor.
D insulator.

1.1.2 Which ONE of the following is not a characteristic of a resonant circuit in series?

A Capacitive reactance is equal to inductive reactance.
B Impedance is at a maximum.
C Current is at a maximum.
D Impedance is equal to resistance.

1.1.3 Transients in an SCR circuit are at their worst when switched on at:

A 90°
B 180°
C 30°
D 60°

1.1.4 Which ONE of the following quantities cannot be measured by an LVDT transducer?

A Position
B Displacement
C Rotation
D Pressure

1.1.5 An oscilloscope cannot measure …

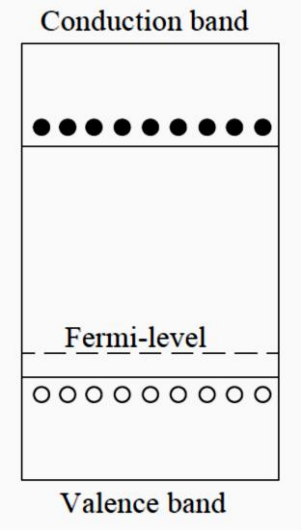
A AC voltage.
B DC voltage.
C AC current.
D frequency.

(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 Kirchhoff's current law states that the algebraic sum of the currents acting in a loop is equal to the applied current.

1.2.2 Fermi levels are a convenient way of showing the distribution of charge carriers in different materials. The figure below shows a fermi level of a P-type material.



1.2.3 An operational amplifier has a low output impedance.

1.2.4 In a class B amplifier the bias point is at the cut-off region.

1.2.5 An SCR cannot be turned on by increasing the anode/cathode voltage over the breakover voltage.

(5 × 1) (5)

1.3 Choose ONE term from the list below for each of the following descriptions and write it next to the question number (1.3.1–1.3.5) in the ANSWER BOOK.

line commutation; common base amplifier; open loop; photosensitive cells; precision; forced commutation; closed loop; common collector amplifier; photoconductive cells; accuracy

1.3.1 When the output of an amplifier circuit is monitored and fed back to the input, corrective action can be taken.

1.3.2 Closeness with which an instrument reading come within reach of the true value of the variable being measured.

1.3.3 Whenever an AC signal crosses zero from positive to negative, the anode becomes negative with respect to the cathode and the SCR turns off.

1.3.4 Semiconductor device that will generate a voltage when incandescent light activates the cell.

1.3.5 Amplifier that produces a high voltage gain.

(5 × 1) (5)

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1.4 Choose a term 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	Diode circuit that cuts of the positive part of a wave form	A	positive clipper
1.4.2	Positive terminal of a battery connected to the N-type material of a PN junction diode	B	covalent bonds
1.4.3	Errors occurring as a result of mistakes made by humans when using measuring instruments	C	reverse current
1.4.4	Amount of current that will leak through the diode at various reverse voltages	D	gross errors
1.4.5	Mutual sharing of electrons between atoms to complete their valence shells	E	forward biasing
		F	maximum repetitive reverse current
		G	atomic bonds
		H	negative clipper
		I	reverse biasing
		J	random errors

(5 × 1) (5)

[20]

TOTAL SECTION A: 20

SECTION B

QUESTION 2: DC THEORY AND AC THEORY

2.1

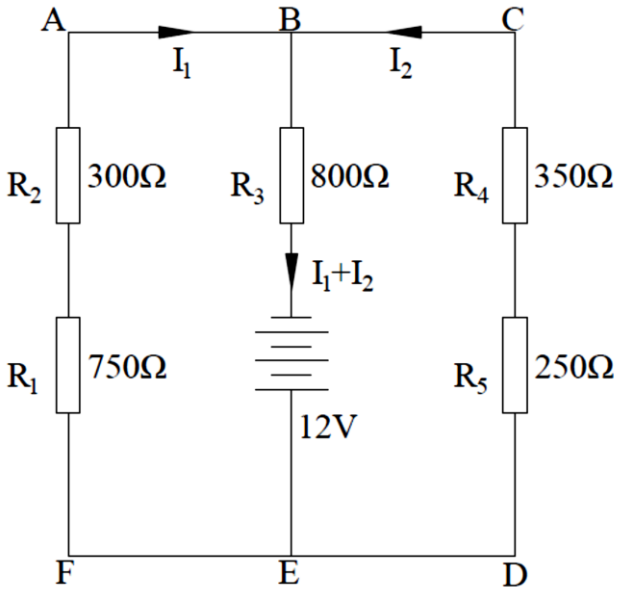


FIGURE 1

Determine the values of the unknown currents I_1 and I_2 shown in FIGURE 1. Use loop EFAB and loop EDCB. (9)

2.2 The circuit shown in FIGURE 2 resonates at 4 kHz.

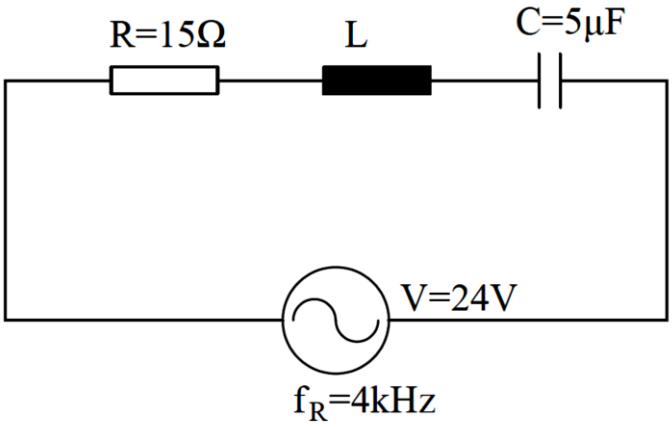


FIGURE 2

2.2.1 Calculate the value of the inductor (L). (4)

2.2.2 Calculate the total current. (2)

2.2.3 Calculate the value of the voltage drop over the inductor and capacitor. (3)

[18]

QUESTION 3: SEMICONDUCTOR DIODES AND TRANSDUCERS

3.1 The purpose of a clipper is to cut off a voltage above or below a pre-set value.

3.1.1 Draw a circuit diagram of a positive parallel clipper. (3)

3.1.2 Draw the input and output waveform of a negative series clipper. (2)

3.2 Draw a neat, labelled circuit diagram of a simple voltage regulator that uses a Zener diode for voltage stabilisation. (4)

3.3 When the light intensity on the PN junction of a photodiode increases so will the leakage current.

Draw the characteristic curve of a photodiode. (3)

3.4 What is the purpose of an optocoupler? (1)

3.5 Explain, with the aid of a sketch, the working principle of a Wheatstone bridge. (4)

3.6 A strain gauge is a resistive transducer.

3.6.1 Explain the operating principle of a strain gauge. (1)

3.6.2 Give TWO applications of strain gauges. (2)

[20]

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QUESTION 4: SEMICONDUCTOR TRANSISTORS AND ELECTRONIC POWER CONTROL

4.1 Draw a neat, labelled circuit diagram of a common base amplifier. (4)

4.2 FIGURE 3 shows a common emitter amplifier with three necessary values of some of the components.

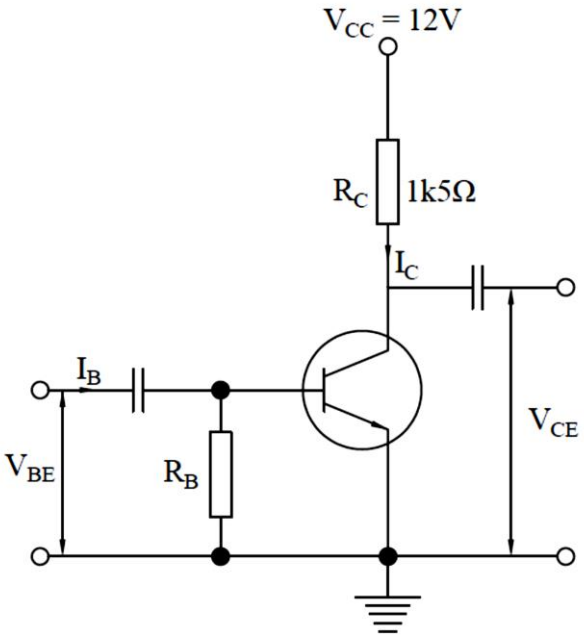


FIGURE 3

Draw a neat, labelled graph and show the DC load line by using the given information. (3)

4.3 Draw a neat, labelled circuit diagram where a transistor is used as a series voltage regulator. (3)

4.4 A phototransistor is similar to a normal transistor except for the window that will concentrate light on the base-collector junction.

4.4.1 Draw the IEC symbol for a phototransistor. (1)

4.4.2 Draw the characteristic curve of a phototransistor. (2)

4.5 Draw a neat, labelled circuit diagram where a MOSFET is used in an amplifier circuit. (4)

4.6 Draw a neat, labelled circuit diagram where an SCR is used in full-wave control using only two SCRs. (4)

4.7 Draw a graphical representation of how cyclotronic control is achieved. (3)

[24]

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QUESTION 5: MEASURING INSTRUMENTS AND OPERATIONAL AMPLIFIERS

5.1 Draw a neat, labelled block diagram of a continuous-balance digital voltmeter. (5)

5.2 Explain the purpose of delay lines in an oscilloscope. (3)

5.3 Explain the basic operation of a cathode-ray tube. (4)

5.4 An OP amp is a high-gain direct-coupled amplifier with a wide frequency range.

5.4.1 Draw a circuit diagram of a summing OP amp. (4)

5.4.2 Draw the output waveform of a differentiator if the input wave is a square wave as indicated in FIGURE 4.

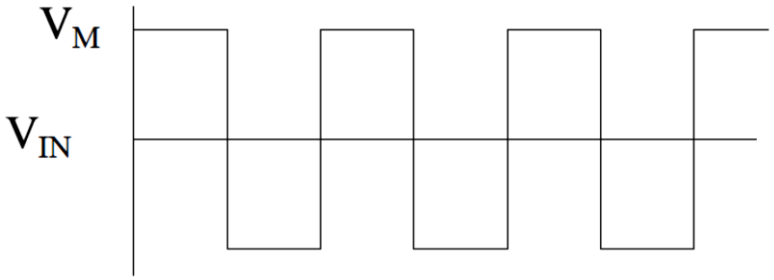


FIGURE 4 (2)

[18]

TOTAL SECTION B: 80

GRAND TOTAL: 100

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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

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

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