higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N3

(8080613)

18 November 2016 (X-Paper)
09:00–12:00

Calculators may be used.

This question paper consists of 8 pages and 1 formula sheet.

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. Use only BLUE or BLACK ink.
5. ALL the final answers must be approximated accurately to THREE decimal places.
6. Use $\pi = 3,142$.
7. Write neatly and legibly.

QUESTION 1

1.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (1.1.1–1.1.7) in the ANSWER BOOK.

1.1.1 The collector current of a transistor will increase when the base/ emitter forward-bias voltage is increased.

1.1.2 The direct-current bias point is a point on the load line which represents the currents in a transistor and the voltage across it when no signal is applied.

1.1.3 Current can flow through a Zener diode in both directions.

1.1.4 An electron has a negative charge of approximately $1,602 \times 10^{-19}$ coulombs.

1.1.5 The algebraic sum of the voltages across the series components in an alternating-current circuit is equal to the supply voltage.

1.1.6 In positive temperature coefficient thermistors the resistance increases with an increase in temperature.

1.1.7 The larger the delay angle in a speed-control circuit, the higher the speed.

(7 × 1) (7)

1.2 Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A–C) next to the question number (1.2.1–1.2.7) in the ANSWER BOOK.

1.2.1 An SCR can be switched off by …

A a negative pulse on the gate.
B increasing the current to above the holding current.
C making the anode negative with respect to the cathode.

1.2.2 The smallest change in measured value to which an instrument will respond is called the …

A resolution.
B sensitivity.
C precision.

1.2.3 The number of electrons that pentavalent atoms have in their outer shell is …

A 3.
B 4.
C 5.

1.2.4 A transistor has an emitter current of 22 mA and a collector current of 21 mA. The base current is …

A 43 mA.
B 1 mA.
C 22 mA.

1.2.5 The main characteristics of an operational amplifier are:

A Very high output impedance, low input impedance, high voltage gain, ability to handle both AC and DC signals
B Very high voltage gain, high input impedance, low output impedance, ability to handle both AC and DC signals
C Very high voltage gain, high current gain, low output impedance, high input impedance

1.2.6 Which ONE of the following statements is WRONG?

A An inductive reactance results in a lagging phase angle.
B Reactance is resistance to electron flow in an alternating-current circuit.
C Resistance varies as the frequency of the supply is varied.

1.2.7 Resonance can occur only in a circuit which contains …

A resistance and capacitance.
B resistance and inductance.
C inductance and capacitance.

(7 × 1) (7)
[14]

QUESTION 2

2.1 Study FIGURE 1 below and determine the following with the aid of Kirchhoff's laws:

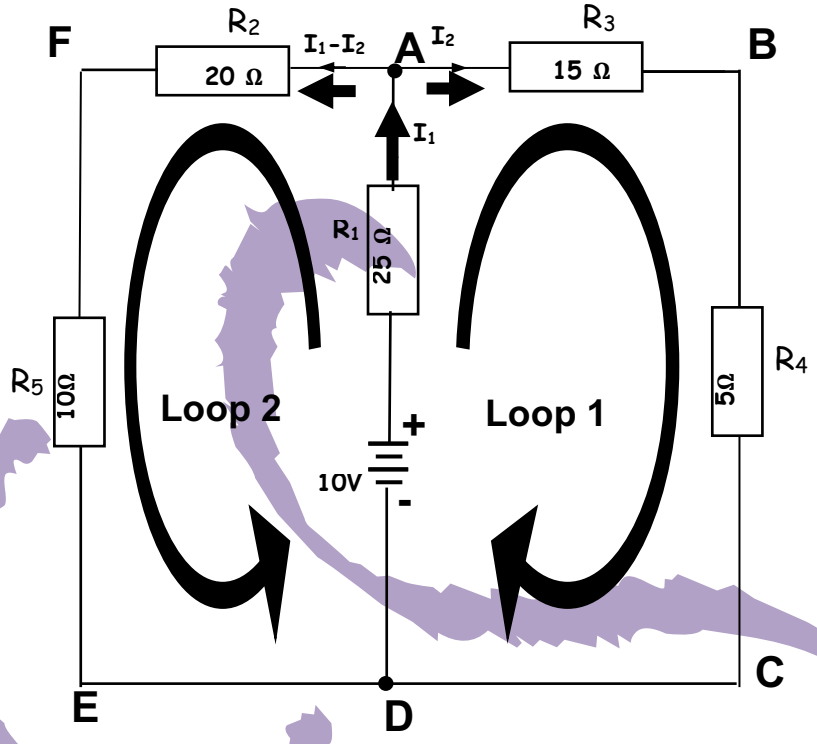

FIGURE 1

2.1.1 The equation for Loop 1 (ABCDA) – set up the equation by starting at point A and proceed in the direction of Loop 1 (thick arrow) (2)

2.1.2 The equation for Loop 2 (AFEDA) – set up the equation by starting at point A and proceed in the direction of Loop 2 (thick arrow) (2)

2.1.3 The magnitude of the currents I_1 and I_2 by making use of the equations in QUESTION 2.1.1 and QUESTION 2.1.2 (4)

2.2 If the current is at minimum, calculate the capacitor when the coil with the resistor of 12 Ω and the inductor of 32 mH is connected in parallel to the unknown capacitor. This circuit diagram is then connected to a 240 V/50 Hz supply. (10)
[18]

QUESTION 3

3.1 An SCR can be controlled by making use of four different methods. The statements below are descriptions or definitions of these methods.

Name the method that best describes the given statement:

3.1.1 This method of control is achieved by switching the control device on for a number of full cycles and then switching the control device off for a number of full cycles.

3.1.2 This method of control is a combination of phase control and cycle control.

3.1.3 This method of control is achieved by controlling the time at which the gate of the SCR is triggered.

3.1.4 This method of control is used when the SCR performs simple switching.

(4 × 1) (4)

3.2 Show, by means of a labelled circuit diagram, how two SCRs connected to form an SCR diode bridge can be used for full-wave control. (4)

3.3 Choose the correct word(s) from those given in brackets. Write only the word(s) next to the question number (3.3.1–3.3.5) in the ANSWER BOOK.

3.3.1 Crystal transducers make use of the (a) (photoelectric effect/piezo-electric effect) and they develop voltage when (b) (subjected to a force/exposed to light). (2)

3.3.2 A common-emitter amplifier has a phase shift of (a) (0°/180°), a (b) (high/low) current gain and a (c) (high/low) voltage gain. (3)

3.3.3 The output of a series clipper is measured across the (a) (diode/resistor) and the output of a parallel clipper is measured across the (b) (diode/resistor). (2)

3.3.4 A (a) (dual-beam/dual-trace) oscilloscope has two electron guns and a (b) (dual-beam/dual-trace) oscilloscope has two modes of operation. (2)

3.3.5 The (JFET/MOSFET) has its gate terminal insulated from the channel. (1)

[18]

QUESTION 4

4.1 Draw a neat, labelled circuit diagram of a push-pull amplifier. Indicate on the circuit ALL relevant waveforms and bias polarities. (7)

4.2 Briefly describe the operation of each of the following amplifiers:

4.2.1 Class A

4.2.2 Class B

(2 × 2) (4)

4.3 Choose a description from COLUMN B that matches an item in COLUMN A. Write only the letter (A–C) next to the question number (4.3.1–4.3.3) in the ANSWER BOOK.

COLUMN A		COLUMN B	
4.3.1	BJT	A	insulated-gate field-effect transistor
4.3.2	MOSFET	B	voltage-controlled device
4.3.3	FET	C	current-operated device

(3 × 1) (3)

4.4 Name TWO applications of an LED. (2)

4.5 A varactor diode can be used as a (4.5.1) and it can act as a (4.5.2) -biased diode. (2)

[18]

QUESTION 5

5.1 Name the FOUR main characteristics of operational amplifiers. (4)

5.2 Draw neat, labelled circuit diagrams of an operational amplifier used in the following modes:

5.2.1 Summing

5.2.2 Integrator

(2 × 3) (6)

5.3 Define the term *Fermi level.* (2)

5.4 Draw neat, labelled sketches of the following bonds:

5.4.1 Covalent bond

5.4.2 Ionic bond

(2 × 2) (4)

5.5 Give an explanation for V_F in terms of diode parameters. (2)
[18]

QUESTION 6

6.1 Refer to FIGURE 2 below and answer the questions.

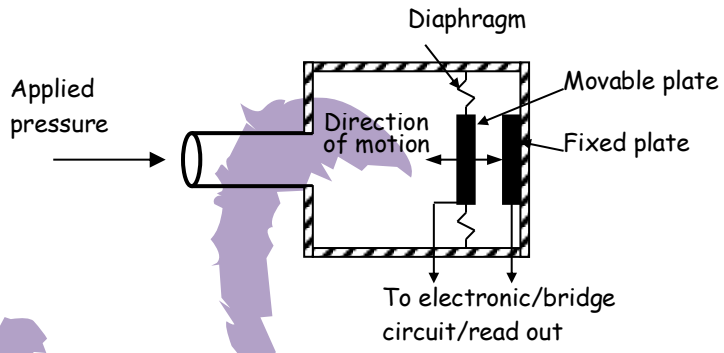

FIGURE 2

6.1.1 Identify the transducer in FIGURE 2. (1)

6.1.2 Briefly explain the operating principle of the transducer in FIGURE 2. (2)

6.1.3 Name ONE area of application. (1)

6.2 Describe how a selenium photovoltaic cell is used as a transducer by providing the following:

6.2.1 A labelled sketch of the construction (4)

6.2.2 The basic principle of operation (2)

6.3 With reference to an oscilloscope describe the purpose of the following:

6.3.1 Deflection plates

6.3.2 Delay line

(2 × 2) (4)
[14]

TOTAL: 100

INDUSTRIAL ELECTRONICS N3

FORMULA SHEET

Direct-current theory

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

$P = I^2 \cdot R$

Alternating-current theory

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

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

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

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

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

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

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

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

Transistors

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

Transducers

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