higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T690(E)(N17)T

NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N3

(8080613)

17 November 2014 (Y-Paper)
13:00–16:00

Candidates will require drawing instruments.

Calculators may be used.

This question paper consists of 7 pages, 1 formula sheet and 1 diagram 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. ALL the sketches and diagrams must be large, clear and neat.
5. ALL the final answers must be approximated accurately to THREE decimal places.
6. Questions must be answered in BLUE or BLACK ink.
7. Use $\pi = 3,142$.
8. Keep questions and subsections of questions together.
9. Start each question on a NEW page.
10. Write neatly and legibly.

SECTION A

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 (1.1.1–1.1.10) in the ANSWER BOOK.

1.1.1 A positive pulse on the gate of an SCR will allow the SCR to switch on.

1.1.2 A dual-trace oscilloscope is equipped with two electron guns and two pairs of vertical deflection plates.

1.1.3 Field-effect transistors are current-operated devices.

1.1.4 Kirchhoff's current law states that the algebraic sum of the currents entering and leaving a point is equal to zero.

1.1.5 Pure semiconductor material is referred to as extrinsic material.

1.1.6 Capacitive transducers only operate from a DC supply.

1.1.7 Static forward voltage of a diode is the minimum forward voltage drop for a given forward current.

1.1.8 A common-base amplifier has a 0° phase shift between input and output.

1.1.9 The current is a maximum in a RLC parallel resonant circuit.

1.1.10 Human errors are also referred to as random errors.

(10×1) (10)

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 (1.2.1–1.2.10) in the ANSWER BOOK.

1.2.1 When increasing the frequency to a value above the resonant frequency in a series circuit, the impedance …

A decreases and the circuit becomes capacitive.
B increases and the circuit becomes capacitive.
C increases and the circuit becomes inductive.

1.2.2 Donor doping is achieved by adding impurity atoms, which have ... valence electrons to the silicon.

A 3
B 4
C 5

1.2.3 The transducer used to indicate direction of applied motion is a ...

A Wheatstone bridge.
B linear variable differential transformer.
C strain gauge.

1.2.4 The output voltage of a four-diode full-wave rectifier is ... that of a two-diode full-wave rectifier.

A greater than
B less than
C equal to

1.2.5 The device that develops a voltage when it is exposed to light, is referred to as a ...

A photoconductive cell.
B light-emitting diode.
C photovoltaic cell.

1.2.6 The ... diodes are normally used in the reverse-bias condition.

A PN-junction, Zener and varactor
B photo, Zener and varactor
C PN-junction, photo and Zener

1.2.7 In a series-resonant circuit, the following conditions exist:

A Z is a minimum, I is a maximum
B Z is a maximum, I is a maximum
C Z is a maximum, I is a minimum

1.2.8 The forbidden energy gap for a conductor is ...

A small.
B large.
C non-existent.

1.2.9 One section of the vertical-deflection system of an oscilloscope is the ...

A probe.
B trigger circuit.
C time-base generator.

1.2.10 The operational amplifier of which the output signal is 180° out of phase with the input signal, is the ...

A inverting amplifier.
B non-inverting amplifier.
C voltage follower.

(10 × 1) (10)
[20]

TOTAL SECTION A: 20

SECTION B

QUESTION 2

2.1 Study FIGURE 1 on the DIAGRAM SHEET (attached) and determine with the aid of Kirchhoff's laws:

2.1.1 The equation for loop 1 (AFEDCBA). Set up the equation by starting at point A and proceed in the direction of loop 1. (2)

2.1.2 The equation for loop 2 (ADEFA). Set up the equation by starting at point A and proceed in the direction of loop 2. (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 Make use of the input waveform in FIGURE 2 on the DIAGRAM SHEET (attached) to draw the corresponding output waveform and circuit diagram for:

2.2.1 A series positive clipper

2.2.2 A parallel positive clipper

(NOTE: Assume $V_F = 0$ for a diode) (2 × 4) (8)
[16]

QUESTION 3

3.1 A resonant series circuit consists of an inductor of 150 mH, a resistance of 4 ohms and a variable capacitor. This series circuit is connected across a 220 volt 60 Hz supply.

Calculate the:

3.1.1 Value of the capacitor at resonance

3.1.2 Voltage across the capacitor and the inductor

(2 × 4) (8)

3.2 Explain a varactor diode by drawing the following:

3.2.1 A symbol (1)

3.2.2 The characteristic curve (3)

3.2.3 A circuit diagram to show how it is used in a tuning circuit (4)
[16]

QUESTION 4

4.1 Refer to FIGURE 3 on the DIAGRAM SHEET (attached).

4.1.1 Identify the circuit. (1)

4.1.2 The following is an explanation of the operation of this circuit. Choose the correct word from those given in brackets and write only the word next to the question number (a–f) in the ANSWER BOOK.

If I_L decreases, then I_C (a) (decreases/increases), resulting in a (b) (rise/drop) in the voltage across R_L.

The decrease also results in a (c) (decrease/increase) in I_E, which is almost equal to I_C.

This (d) (decreases/increases) the voltage across R_E, causing the voltage of the emitter-to-base to (e) (decrease/increase) and so the conductivity of the transistor (f) (decreases/increases). This causes I_L to stay at a constant level. (6)

4.2 Name THREE classes of amplification. (3)

4.3 Name SIX advantages of field-effect transistors. (6)
[16]

QUESTION 5

5.1 Describe how TWO strain gauges are used in a Wheatstone bridge by providing the following:

5.1.1 A labelled circuit diagram of the Wheatstone bridge showing how the strain gauges are connected (4)

5.1.2 The basic principle of operation of a strain gauge (2)

5.1.3 TWO examples of where it is used (2)

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

5.3 Show, with the aid of neat, labelled sketches, the width of the forbidden gaps for each of the following:

5.3.1 An insulator

5.3.2 A semiconductor

(2 × 2) (4)
[16]

QUESTION 6

6.1 Draw and label block diagram of a frequency counter. (Use arrows to indicate data flow.) (7)

6.2 Name TWO types of errors pertaining to measuring instruments and provide a cause of each error. (4)

6.3 Illustrate a light-emitting diode (LED) by drawing the following:

6.3.1 A labelled circuit symbol (2)

6.3.2 A circuit diagram to show how it is used in an opto-coupler with a photodiode (3)
[16]

TOTAL SECTION B: 80
GRAND TOTAL: 100

INDUSTRIAL ELECTRONICS N3

FORMULA SHEET

Direct current theory:

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

$P = I^2 \cdot R$

Alternating current theory:

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

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

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

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

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

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

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

$I_C = I_{RL} \sin \theta_L$ $\quad I_T = I_{RL}\cos\theta_L$ $\quad I_T = \sqrt{I_{T_H}^{\,2} + I_{T_V}^{\,2}}$

Transistors:

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

Transducers:

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

DIAGRAM SHEET

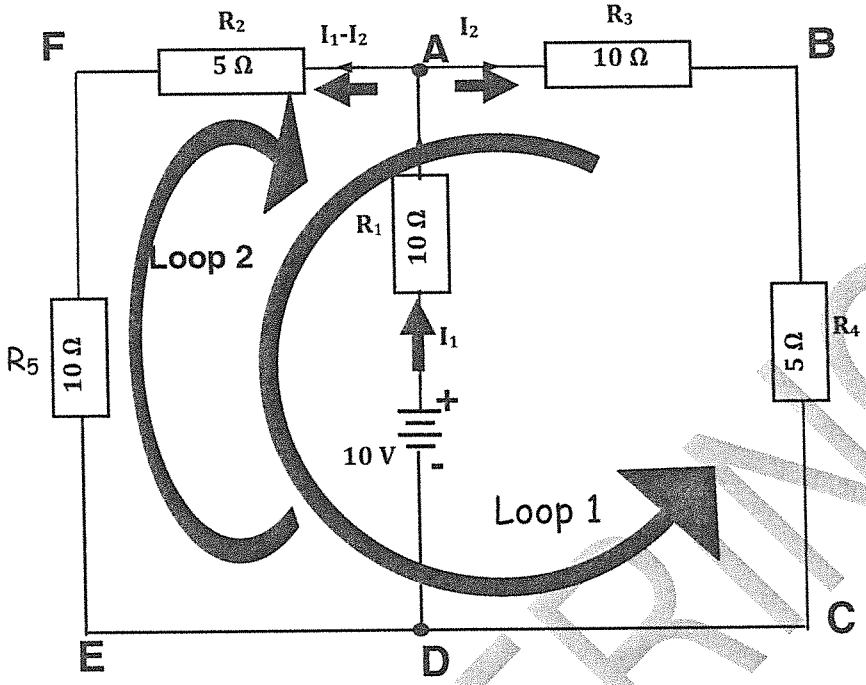

FIGURE 1

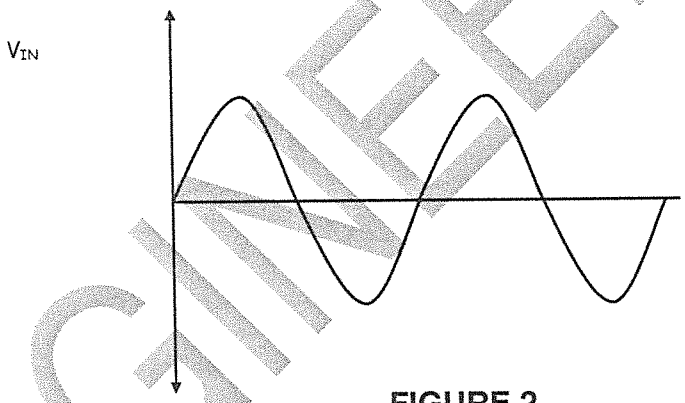

FIGURE 2

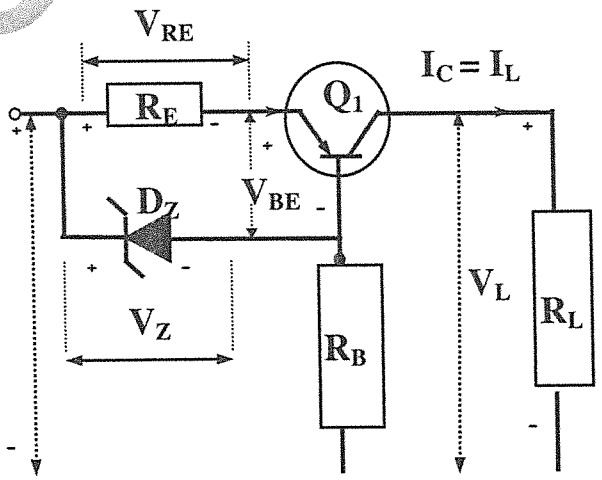

FIGURE 3