higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T710(E)(A1)T

APRIL EXAMINATION

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N3

(8080613)

1 April 2015 (Y-Paper)
13:00–16:00

Candidates require drawing instruments.

Calculators may be used.

This question paper consists of 7 pages, 1 diagram sheet 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 correctly 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. Keep questions and subsections of questions together.
7. Questions must be answered in BLUE or BLACK ink.
8. Use $\pi = 3,142$.
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 (1.1.1–1.1.5) in the ANSWER BOOK.

1.1.1 In a capacitor, the applied voltage leads the line current.

1.1.2 Light sensitive devices that radiate light are known as photo-emission devices.

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

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

1.1.5 An SCR has three junctions.

(5 × 1) (5)

1.2 Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question number (1.2.1–1.2.5) in the ANSWER BOOK.

1.2.1 Resonance can occur only in a circuit which contains …

A resistance and capacitance.
B resistance and inductance.
C inductance and capacitance.
D inductance only or capacitance only.

1.2.2 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
D very high output impedance, high input impedance, high voltage gain, ability to handle both AC and DC signals.

1.2.3 Negative ions are atoms that …

A are electrically neutral.
B have lost an electron.
C have gained an electron.
D have lost a proton.

1.2.4 The following statement about reactance 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 A capacitive reactance results in a leading phase angle.
D Reactance is not influenced by the frequency of the supply.

1.2.5 A phototransistor switches on when the … is (are) exposed to light.

A base-emitter junction
B base-collector junction
C base-emitter and base-collector junctions
D base-emitter or base-collector junction

(5 × 1) (5)

1.3 Choose the correct word(s) from those given in brackets. Write only the word(s) next to the question number (1.3.1–1.3.5) in the ANSWER BOOK.

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

1.3.2 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)

1.3.3 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)

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

1.3.5 Crystal transducers makes use of the (a) (photo-electric/piezo-electric) effect and they develop a voltage across them when (b) (subjected to a force/exposed to light). (2)

[20]

TOTAL SECTION A: 20

SECTION B

QUESTION 2

2.1 Study FIGURE 1 on the attached DIAGRAM SHEET 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 (ADCBA). 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 The following paragraph explains the doping processes. Select the correct word from the options provided that would make the statements true.

The *deliberate* addition of controlled amounts of foreign atoms or impurities to a pure or intrinsic semiconductor is called doping.
If a (2.2.1 *pentavalent/ trivalent*) impurity atom (5 valence electrons) was added, an *excess* of (2.2.2 *holes/electrons*) would be produced. This process is called (2.2.3 *acceptor/donor*) doping and results in (2.2.4 *P-type/N-type*) material being formed. In this type of material, the majority charge carriers are the (2.2.5 *holes/electrons*).

However, if a (2.2.6 *pentavalent/trivalent*] atom (an atom that has 3 valence electrons) was added, an excess of (2.2.7 *holes/electrons*) will result and this process is called (2.2.8 *acceptor/donor*) doping. This process results in (2.2.9 *P-type/N-type*) material being formed. Here the majority charge carriers are (2.2.10 *holes/electrons*). (5)

2.3 Draw a labelled circuit diagram of a half-wave voltage doubler. (3)
[16]

QUESTION 3

3.1 Consider the phasor diagram in FIGURE 2 on the attached DIAGRAM SHEET and determine the following:

3.1.1 The value of the inductor in mH (3)

3.1.2 The value of the capacitor in μF (3)

3.1.3 Supply current (2)

3.1.4 Phase angle (2)

NOTE: The supply frequency is 50 Hz.

3.2 Transients occur when an SCR is switched on and can have disastrous consequences for the circuit.

Name the TWO methods used to eliminate transients. (2)

3.3 For full-wave control of a load a bridge circuit as shown in FIGURE 3 on the DIAGRAM SHEET can be used.

3.3.1 Redraw the bridge circuit of FIGURE 3 to show how it can be used to control an AC load. (2)

3.3.2 Redraw the bridge circuit of FIGURE 3 to show how it can be used to control a DC load. (2)
[16]

QUESTION 4

4.1 Show, with aid of a labelled circuit diagram, how series-current negative feedback is achieved. (6)

4.2 The most important characteristic of a transistor when used as a switch is its operating or switching speed.

Refer to FIGURE 4 on the DIAGRAM SHEET and name each of the following:

4.2.1 t_a

4.2.2 t_b

4.2.3 t_c

4.2.4 t_d

4.2.5 t_e

4.2.6 t_f

(6×1) (6)

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

4.3.1 Class A (2)

4.3.2 Class B (2)
[16]

QUESTION 5

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

5.1.1 A labelled sketch of the construction (4)

5.1.2 The basic principle of operation (2)

5.1.3 ONE area of application (1)

5.2 Name the FIVE groups into which transducers can be divided. (5)

5.3 Using the input waveform given in FIGURE 5 of DIAGRAM SHEET 1, draw the corresponding output waveforms for the following operational amplifiers (5.3.1–5.3.2) in the ANSWER BOOK.

5.3.1 Integrator (2)

5.3.2 Differentiator (2)
[16]

QUESTION 6

6.1 Draw a neat, labelled block diagram of a successive-approximation digital voltmeter. (8)

6.2 Explain the purpose of a cathode-ray tube as used in an oscilloscope. (2)

6.3 Briefly explain the operating principle of the following diodes:

6.3.1 Varactor diode (3)

6.3.2 Photodiode (3)
[16]

TOTAL SECTION B: 80
GRAND TOTAL: 100

DIAGRAM SHEET

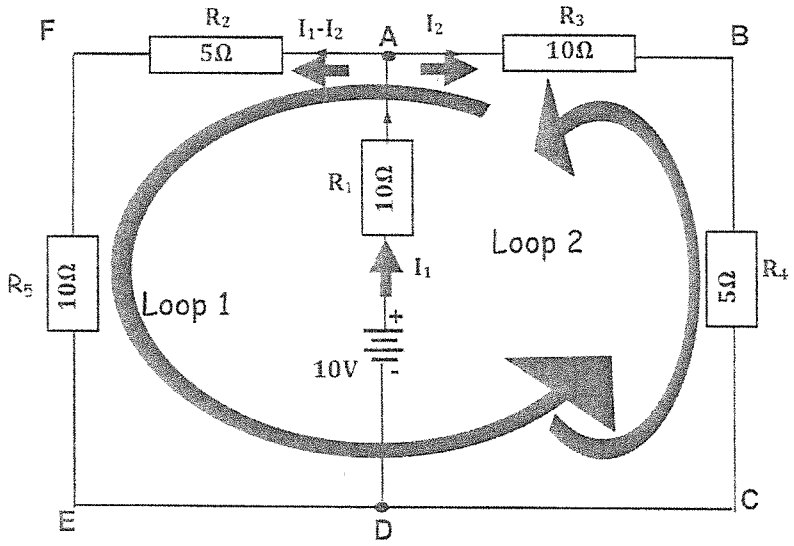

FIGURE 1

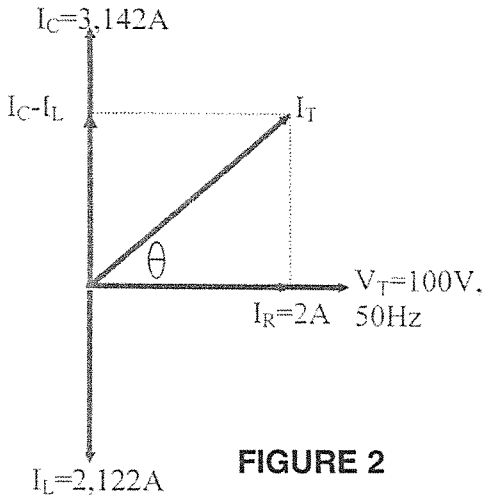

FIGURE 2

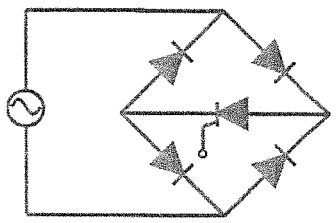

FIGURE 3

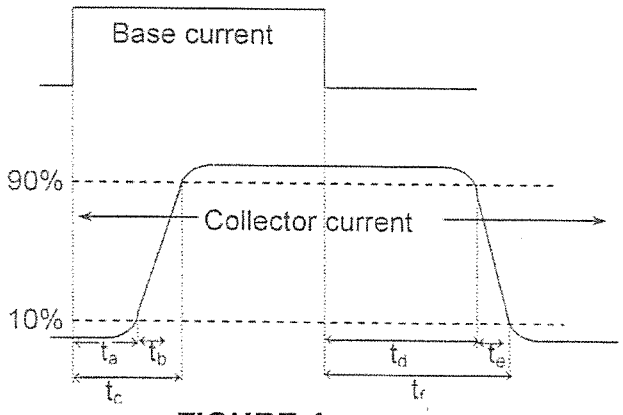

FIGURE 4

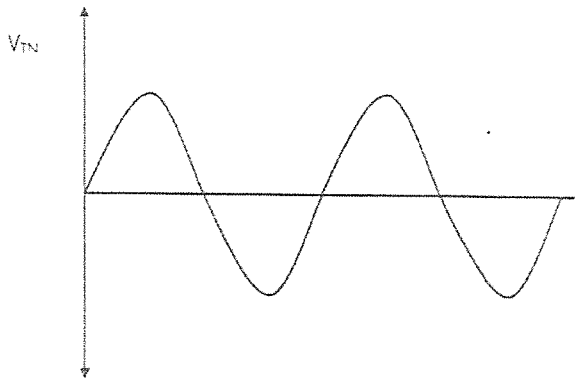

FIGURE 5

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:

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