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Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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NOVEMBER 2010

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N3

(8080613)

18 November (X-Paper)
09:00 – 12:00

Candidates will require drawing instruments, pens and a ruler.

Calculators may be used.

This question paper consists of 7 pages, a diagram sheets, a 1-page formula sheet and ANSWER 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. Start each question on a NEW page.
4. ALL the sketches and diagrams must be large, clear and neat.
5. Keep questions and subsections of questions together.
6. Leave margins clear.
7. Questions must be answered in BLUE or BLACK INK.
8. Use $\pi = 3,142$.
9. ALL the final answers must be approximated accurately to THREE decimal places.
10. Number the answers correctly according to the numbering system used in this question paper.
11. 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 An inductor is connected in parallel with a capacitor. If the inductance is doubled and the capacitance is halved, the impedance at resonance will be doubled.

1.1.2 The graph showing the variation of inductive reactance with frequency, is a straight line.

1.1.3 The equation: $V_T = I_1R_2 + (I_1 - I_2)R_4 - I_2R_1$ is an example of Kirchhoff's current law.

1.1.4 Doping improves the conduction capabilities of a semiconductor.

1.1.5 Transition capacitance occurs when a PN-junction is reverse biased.

1.1.6 Zener breakdown occurs when the applied electric field pulls the electrons from the covalent bonds.

1.1.7 An advantage of field effect transistors is the very high output impedance.

1.1.8 RC coupling amplifiers does not have a good frequency response.

1.1.9 Forced commutation is used in alternating current circuits.

1.1.10 A negative temperature coëfficient (NTC) thermistor's resistance decreases with increasing temperature. (10 x 1) (10)

1.2 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 (1.2.1 – 1.2.9) in the ANSWER BOOK.

1.2.1 In the circuit shown in FIGURE 1, on the DIAGRAM SHEET 2, if L and R remain fixed, the effect of increasing C will be to ...

A increase the resonant frequency.
B reduce the dynamic impedance.
C increase the dynamic impedance.
D increase the capacitive reactance. (1)

1.2.2 The phasor diagram in FIGURE 2, on DIAGRAM SHEET 2, represents an alternating voltage and current where ...

A I lags V by 25°.
B I leads V by 25°.
C V lags I by 65°.
D V leads I by 65°. (1)

1.2.3 In the circuit shown in FIGURE 3 on DIAGRAM SHEET 2, which ONE of the following equations is correct?

A $-10 = 2\,(I_1 - I_2) + 6\,(I_1 - 1{,}1) + 2\,I_1$
B $10 = 6\,I_2 + 5\,(I_2 - 1{,}1) - 2\,(I_1 - I_2)$
C $0 = -2{,}2 + 5\,(I_2 - 1{,}1) + 6\,(I_1 - 1{,}1)$
D $0 = 2{,}2 + 5\,(I_2 - 1{,}1) + 6\,(I_1 - 1{,}1)$ (1)

1.2.4 The current flowing in the wire marked P in FIGURE 4, on DIAGRAM SHEET 2 is ...

A 3 A flowing from X to Y.
B 3 A flowing from Y to X.
C 4 A flowing from Y to X.
D 19 A flowing from Y to X. (2)

1.2.5 Light in an LED is generated by ...

A intense heating of the junction, like the filament of a light bulb.
B bound electrons spontaneously leaping out of their sockets creating a photon of light.
C free electrons falling into holes and giving up their energy in the form of electromagnetic radiation.
D the creation of a free electron and a hole. (1)

1.2.6 Which ONE of the following statements of a metallic bond is wrong?

A The valence electrons randomly leave their orbits.
B It is associated with a cloud of free electrons and positive ions.
C All the valence electrons are shared by all the atoms.
D The bond is very strong. (1)

1.2.7 The output voltage of a negative series clipper is equal to ...

A $V_{IN} + 0{,}6$.
B $V_{IN} - 0{,}6$.
C $-(V_{IN} - 0{,}6)$.
D $-V_{IN} - 0{,}6$. (1)

1.2.8 Complete the following statement for a forward biased NPN transistor: The base is positive with respect to the emitter and ...

A the collector is at the same potential as the emitter.
B the collector is more positive than the base.
C the collector is more negative than the base.
D the collector is more negative than the emitter. (1)

1.2.9 Which ONE of the following statements of an operational amplifier, used as an integrator, is wrong?

A The rate at which the output voltage changes is related to the instantaneous value of the input voltage.
B Its output waveform is 180° out of phase with the input voltage.
C Its output waveform is 90° out of phase with the input voltage.
D In its circuit a resistor and a capacitor is used. (1)

TOTAL SECTION A: 20

SECTION B

QUESTION 2

2.1 Study FIGURE 5, on DIAGRAM SHEET 2, and determine the following, with the aid of Kirchhoff's law:

2.1.1 The equation for loop 1 (PQRTUP). Set up the equation by starting at point P and proceed in the direction of loop 1 (thick arrow.) (2)

2.1.2 The equation for loop 2 (QSRQ). Set up the equation by starting at point Q and proceed in the direction of loop 2 (thin 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 An SCR can be controlled by making use of four different methods. Provide a brief explanation of each of the following FOUR methods:

2.2.1 Static control (2)

2.2.2 Phase control (2)

2..2.3 Cycle control (2)

2.2.4 Cyclotronic control (2)

NOTE: NO waveforms are required. **[16]**

QUESTION 3

3.1 A resonant parallel circuit consists of an inductor of 200 mH, a resistance of 4 ohms and a capacitor of 50 μF connected across a 220 volt supply.

Calculate the following:

3.1.1 Resonant frequency (2)

3.1.2 Current through the inductor (3)

3.1.3 Dynamic impedance (2)

3.2 Draw the IEC circuit symbol and a labelled characteristic curve of the following:

3.2.1 Photodiode (3)

3.2.2 Phototransistor (3)

3.2.3 Varactor diode (3)
[16]

QUESTION 4

4.1 The circuit in FIGURE 6, on DIAGRAM SHEET 2, is that of a common emitter amplifier.

4.1.1 Make use of the component values given to calcuate the value of Ic (in mA) and V_{CE} which will enable you to draw the DC load line. (2)

4.1.2 On the attached ANSWER SHEET draw the DC load line. (Hand in this sheet.) (2)

4.1.3 Now indicate the position of a suitable Q-point on the the DC load line so that the transistor will operate as a Class A amplifier. Write the values of I_c, V_{CE} and I_B at this Q-point. (2)

4.1.4 Draw the DC load line on the same axis, if R_c is changed to 4 kΩ. (2)

4.1.5 Draw the DC load line on the same axis, if V_{cc} is changed to 10 V (RC is 2 kΩ). (2)

4.2 Refer to FIGURE 7 on DIAGRAM SHEET 2.

4.2.1 Identify the circuit. (1)

4.2.2 Explain the operation of this circuit. (5)
[16]

QUESTION 5

5.1 Describe how a potentiometer is used as a transducer by providing the following:

5.1.1 A labelled sketch of the construction (3)

5.1.2 The basic principle of operation (1)

5.1.3 Give THREE examples of where it is used. (3)

5.2 Name THREE points that should be considered before a transducer is selected for a particular application. (3)

5.3 Draw the input waveform given in FIGURE 8 on DIAGRAM SHEET 2, and also draw the corresponding output waveforms for the following operational amplifiers in the ANSWER BOOK:

5.3.1 Integrator (2)

5.3.2 Differentiator (2)

5.3.3 Summing amplifier (2)
[16]

QUESTION 6

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

6.2 Briefly explain, with the aid of sketches, the following bonds:

6.2.1 Ionic (2)

6.2.2 Covalent (2)

6.3 Explain the fundamental differences between *dual trace* and *dual beam* oscilloscopes. (4)
[16]

TOTAL SECTION B: 80
GRAND TOTAL: 100

DIAGRAM SHEET 2

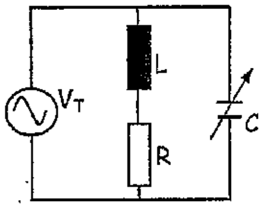

Figure 1

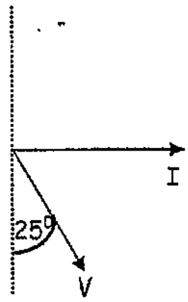

Figure 2

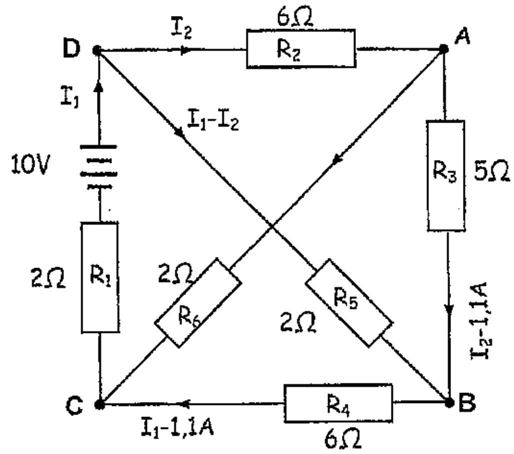

Figure 3

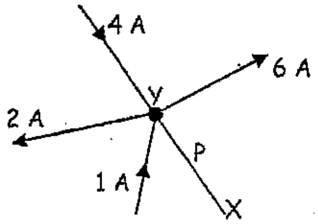

Figure 4

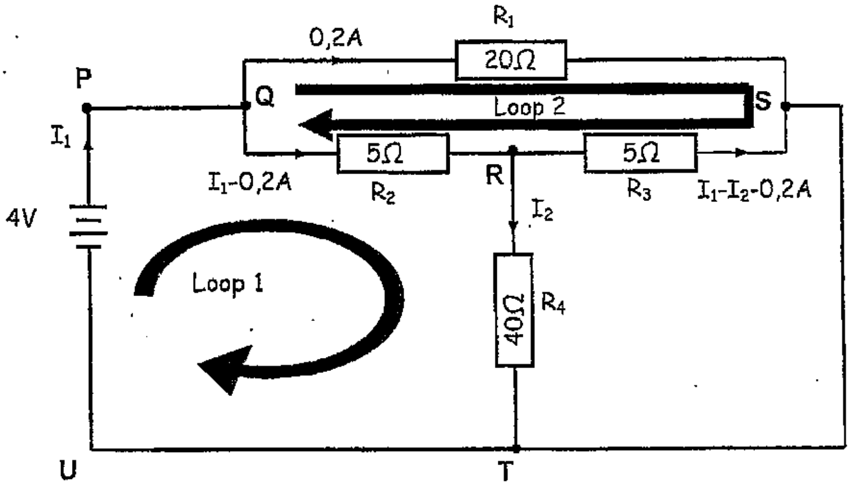

Figure 5

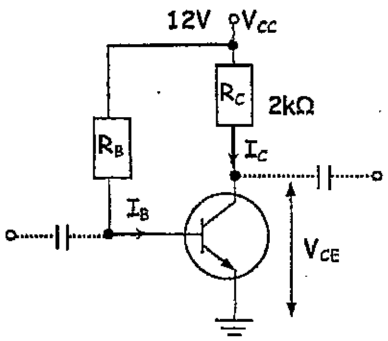

Figure 6

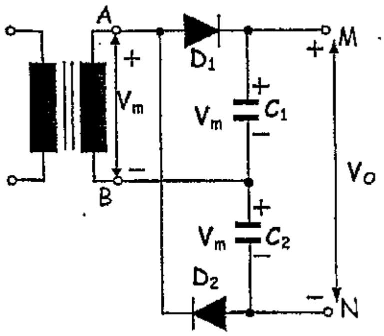

Figure 7

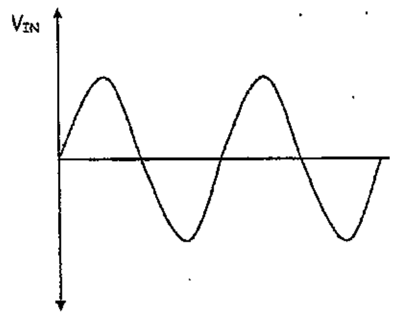

Figure 8

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:

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

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

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

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

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

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

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

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

Transistors:

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

Transducers:

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

EXAMINATION NUMBER:

ANSWER SHEET