2521/105 2602/106
2601/106 2603/106
ELECTRICAL MEASUREMENTS
AND ANALOGUE ELECTRONICS I
June/July 2020
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING
(POWER OPTION)
(TELECOMMUNICATION OPTION)
(INSTRUMENTATION OPTION)
MODULE I

ELECTRICAL MEASUREMENTS AND ANALOGUE ELECTRONICS I

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Mathematical tables/Non-programmable Scientific calculator;
Drawing instruments.
*This paper consists of **EIGHT** questions in **TWO** sections **A** and **B**.*
*Answer **THREE** questions from section **A** and **TWO** questions from section **B** in the answer booklet provided.*
All questions carry equal marks.
Maximum marks for each part of a question are as indicated.
Candidates should answer the questions in English.

This paper consists of 8 printed pages.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.

Turn over

SECTION A: ELECTRICAL MEASUREMENTS

*Answer **THREE** questions from this section.*

1. (a) (i) State **three** essential operational features of galvanometers.

(ii) With the aid of a labelled diagram, describe the measurement of magnetic flux density using the Hall effect.

(10 marks)

(b) Figure 1 shows a circuit diagram of a Wheatstone bridge in which the resistors $P = Q = R = S = 1\,K\Omega$. The galvanometer, G, can detect as low as 0.1 nA. Determine the:

(i) internal resistance of the bridge measured across terminals b - d;

(ii) output voltage due to unbalance condition;

(iii) current through the galvanometer for unbalance condition;

(iv) smallest change in resistance that can be detected.

(8 marks)

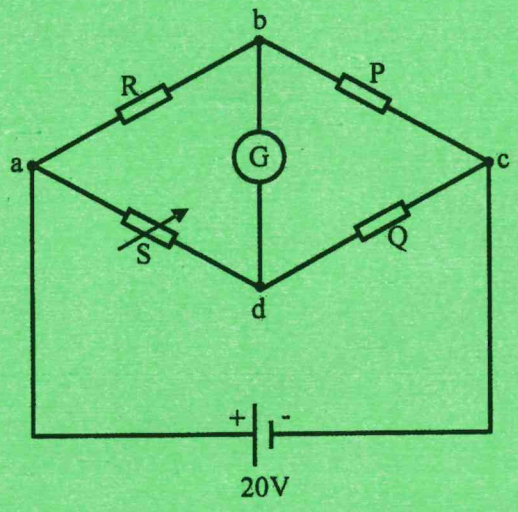

Fig. 1

(c) State **two** sources of errors in measurement of resistance using Wheatstone bridge method. (2 marks)

2. (a) (i) Define each of the following types of failures:

(I) catastrophic;

(II) gradual.

(ii) Sketch the curve of failure rate against time for an electrical equipment and explain its shape.

(10 marks)

(b) Three units, X, Y, and Z, in an electrical system are connected in series. The units have mean time between failures of 20,000 hours, 50,000 hours and 70,000 hours respectively. For an operating period of 1,000 hours, determine the:

(i) reliability of individual units;

(ii) overall reliability of the system;

(iii) probability of failure of the system.

(10 marks)

3. (a) State **four** common faults associated with variable resistors. (4 marks)

(b) Outline the procedure of testing each of the following electrical components using an Ohmmeter:

(i) capacitor;

(ii) iron-cored inductor.

(8 marks)

(c) The average time taken to repair an electrical equipment is $2\frac{1}{2}$ hours. The equipment has a mean time between failure of 10,000 hours. If it takes 6 hours to repair the equipment, determine the:

(i) repair rate;

(ii) maintainability;

(iii) availability.

(6 marks)

(d) Name **two** hand tools used in the repair of d.c. motors. (2 marks)

4. (a) (i) Define each of the following with respect to measurements:

(I) numerical multiplier;

(II) dimension.

(ii) Derive, from first principles, the dimensional equation for charge (Q) in the c.g.s. electrostatic units.

(9 marks)

(b) Table 1 shows various electrical quantities and their units. Match each quantity to its unit. (4 marks)

Table 1

Electrical Quantity	**Unit**
Quantity of electricity	Ampere
Magnetomotive force	Coulomb
Electric field strength	Joule
Energy	Volts per meter

(c) The energy stored per unit volume, W_x, in a parallel plate capacitor is given by the expression:

$$W_x = k\varepsilon^a V^b d^c$$

where k = a constant, ϵ = permittivity of medium, V = voltage across the plates and d = distance between the plates.
Taking the dimensions of $W = [ML^2T^{-2}]$, $\epsilon = [\mu^{-1}L^{-2}T^2]$, $V = [\mu^{-\frac{1}{2}}M^{\frac{1}{2}}L^{\frac{3}{2}}T^{-2}]$ and $d = [L]$, determine the values of the exponents a, b and c. (7 marks)

5. (a) Figure 2 shows a circuit diagram of an a.c. bridge. Obtain the expression for R_1 and L_1 at balance in terms of other circuit components. (7 marks)

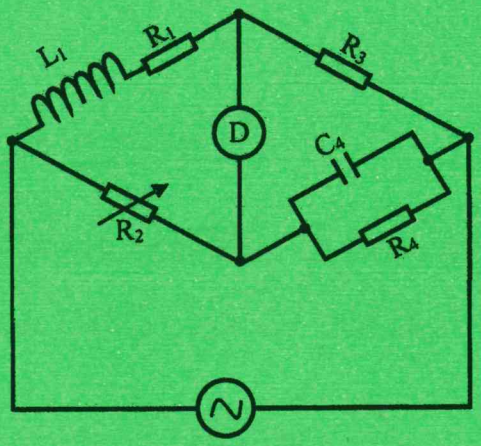

Fig. 2

(b) Figure 3 shows two cycles of a sinusoidal waveform displayed on an oscilloscope. The oscilloscope timebase setting is 2 ms/cm. For the signal, determine the:

(i) period;

(ii) frequency.

(4 marks)

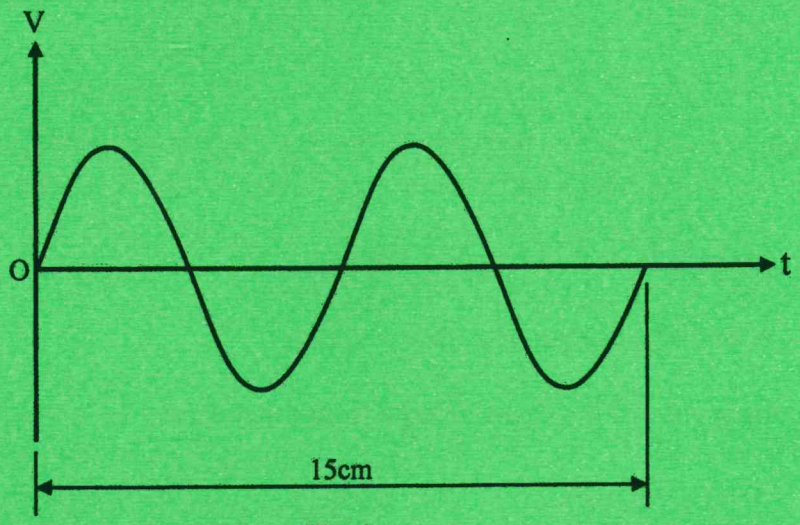

Fig. 3

(c) An electrostatic voltmeter consists of two circular parallel plates, one fixed and one movable, each of diameter 100 mm. When a voltage of 10 kV is applied across the plates, a force of 5×10^{-3} N is exerted on the movable plate causing it to move 1 mm towards the fixed plate. Taking permittivity of free space, $\epsilon_0 = 8.85 \times 10^{-12}$ F/m, determine the:

(i) area of the movable plate;

(ii) distance between the plates;

(iii) resulting change in capacitance.

(6 marks)

(d) State **two** merits and **one** demerit of electrostatic voltmeters. (3 marks)

SECTION B: ANALOGUE ELECTRONICS I

*Answer **TWO** questions from this section.*

6. (a) (i) State **two** demerits of single-phase d.c.-to-a.c. inverters.

(ii) Draw the circuit diagram of a full-wave voltage doubler and describe its operation.

(8 marks)

(b) The primary winding of a transformer feeding a full-wave rectifier is supplied from a 240 V_{rms}, 50 Hz supply and its secondary voltage is 40 V_{rms}. Determine the:

(i) peak value of the secondary voltage;

(ii) output d.c. voltage from the rectifier;

(iii) frequency of the ripple voltage from the rectifier.

(6 marks)

(c) The deflection plates in an electrostatic CRT are 5 mm apart and the voltage applied across them is 120 V_{dc}. The resulting deflection of the beam on the screen is 4 cm. Determine the:

(i) deflection sensitivity;

(ii) deflection factor;

(iii) electric field intensity between the plates.

(6 marks)

7. (a) (i) Define each of the following with respect to bipolar junction transistors:

(I) mutual conductance;

(II) base transmission factor.

(ii) With the aid of a labelled construction diagram, describe the operation of a p-n-p transistor. (10 marks)

(b) Table 2 shows the data for the transfer characteristics of a self-bias junction field effect transistor (JFET) amplifier with a source resistor, $R_S = 2.2\ K\Omega$.

Table 2

Gate - source voltage, V_{GS} (V)	**Drain Current, I_D (mA)**
−6	0.00
−5	0.14
−4	0.55
−3	1.25
−2	2.22
−1	3.47
0	5.00

(i) Plot the curve for I_D against V_{GS}.

(ii) Draw the self bias line.

(iii) Determine the quiescent values of the:

(I) drain current;

(II) gate-source voltage.

(10 marks)

8. (a) (i) State **two** disadvantages of germanium diodes as compared to silicon diodes.

(ii) Figure 4 shows a diagram of a p-n junction diode. State the:

(I) direction in which the barrier potential across the junction acts;

(II) polarity of the applied voltage, V, for reverse bias;

(III) anode and cathode terminals of the diode.

(6 marks)

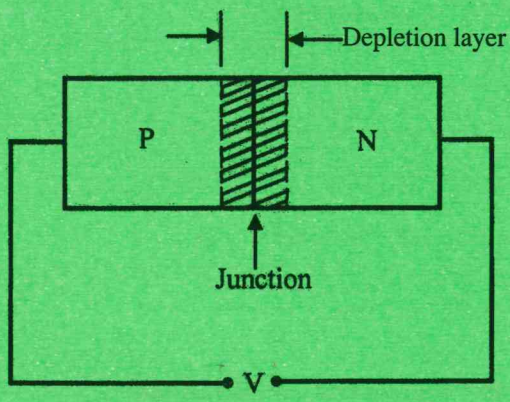

Fig. 4

(b) With the aid of a labelled diagram, describe the formation of an n-type semiconductor.

(6 marks)

(c) (i) State **two** ways by which an electron can be dislodged from the parent atom.

(ii) An electron at an energy level of 10 eV falls to an energy level of 1 eV. Taking Planks constant as 6.625×10^{-34} J – S and mass of electron as 9.1×10^{-31} kg, determine the following for the emitted radiation:

(I) frequency;

(II) velocity;

(III) wavelength.

(8 marks)

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