2521/105 2602/106
2601/106 2603/106
ELECTRICAL MEASUREMENTS AND ANALOGUE ELECTRONICS I
Oct./Nov. 2021
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 any **THREE** questions from section **A** and any **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.

Take: ***Electron charge,*** $e = 1.6 \times 10^{-19} C$
Electron mass, $m = 9.1 \times 10^{-31} kg$

This paper consists of 5 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) Describe "standard" with respect to measurements.
(ii) Distinguish between primary and secondary standards. (6 marks)

(b) Derive from first principles, the dimensional equation for magnetic flux density using the LMTI system. (9 marks)

(c) (i) State the derived units for each of the following quantities:

I. density;
II. electric field strength.

(ii) Derive the dimensional equation for momentum. (5 marks)

2. (a) Figure 1 shows the circuit diagram of the Maxwell's inductance-capacitance bridge at balance.

(i) Derive the expressions for the unknown components R_1 and L_1.
(ii) Determine the values of R_1 and L_1 from the expressions in (a)(i). (7 marks)

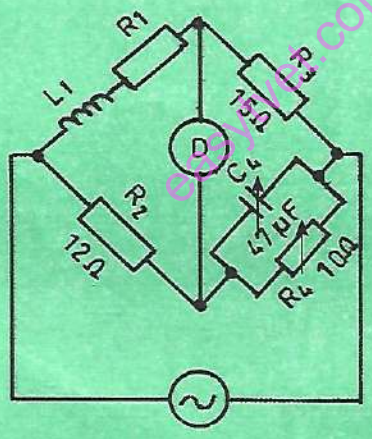

Fig. 1

(b) With aid of a labelled block diagram, describe the operation of a digital frequency meter. (7 marks)

(c) The coil of a permanent magnet moving coil instrument has a resistance of 5Ω and requires a current f 15 mA for full-scale deflection. Determine the resistance to be connected in:

(i) parallel to enable the instrument read up to 1 A;
(ii) series to enable the instrument read up to 15 V. (6 marks)

3. (a) (i) Define each of the following with respect to the operation of electrical equipment:

I. reliability;
II. failure;
III. mean time to fail.

(ii) Sketch the reliability and unreliability curves against time and explain their shape. (10 marks)

(b) Two units, X and Y, have MTBFs of 20,000 hours and 100,000 hours respectively. The units are connected in parallel and the resulting system is operated for a period of 1,000 hours. Determine the:

(i) reliability of each unit;
(ii) unreliability of each unit;
(iii) probability of failure of the system;
(iv) system reliability. (10 marks)

4. (a) (i) State **three** activities that may be carried out in an equipment during routine maintenance.
(ii) Explain preventive maintenance. (6 marks)

(b) With aid of labelled block diagrams, distinguish between convergent and divergent arrangements within an electrical system. (6 marks)

(c) An equipment has a failure rate of 0.5×10^{-3}. The average time to repair any fault in the equipment is 2.5 hours. Determine the:

(i) repair rate;
(ii) mean time between failure;
(iii) availability;
(iv) maintainability for a time of 6 hours. (8 marks)

5. (a) (i) State the purpose for each of the following tools:

I. tweezers;
II. solder sucker;
III. crimping tool.

(ii) Outline the procedure of testing a resistor using a digital multimeter. (8 marks)

(b) State **two** failures that can occur in each of the following components and their possible causes:

(i) ceramic capacitors;
(ii) aluminum electrolytic capacitors. (8 marks)

(c) A sinusoidal voltage waveform displayed on an oscilloscope occupies a peak height of 3 cm. If the vertical sensitivity setting is 20 V/cm, determine the r.m.s value of the voltage. (4 marks)

SECTION B: ANALOGUE ELECTRONICS I

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

6. (a) State the **three** operating regions of a bipolar junction transistor. (3 marks)

(b) With aid of a labelled diagram, describe the operation of a n-p-n transistor. (7 marks)

(c) Figure 2 shows a circuit diagram of a JFET amplifier. Taking $I_D = 2.5$ mA, determine the:

(i) gate voltage, V_G;
(ii) source voltage, V_s;
(iii) gate-to-source voltage, V_{GS};
(iv) drain voltage; V_D;
(v) drain-to-source voltage, V_{DS}. (10 marks)

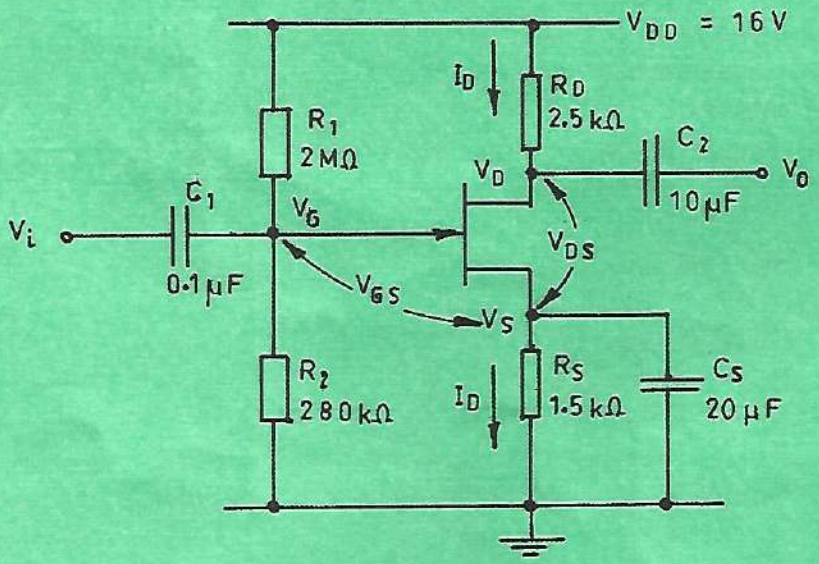

Fig. 2

7. (a) Define each of the following with respect to thermionic emission:

(i) space charge;
(ii) work function. (2 marks)

(b) An electrostatic CRT has parallel deflecting plates 1.5 cm long and 6 mm apart. The screen is 55 cm from the centre of the deflecting plates. The deflecting and accelerating potentials are 150 V and 2.5 kV respectively. Determine the:

(i) velocity of electrons;
(ii) amount of deflection;
(iii) deflection sensitivity of the tube;
(iv) deflection factor of the tube. (8 marks)

(c) (i) Draw the circuit diagram of a single-phase full-wave bridge rectifier and describe its operation.

(ii) Sketch the input and output voltage waveforms for the rectifier in (c)(i). (10 marks)

8. (a) Define each of the following with respect to semiconductors:

(i) ionization potential;
(ii) covalent bonding;
(iii) doping. (3 marks)

(b) Explain Rutherford's atomic model. (4 mark)

(c) Sketch the current-voltage characteristic curve of a p-n diode and explain its shape. (8 marks)

(d) An intrinsic semiconductor has 10^{13} mobile electrons passing through a given point in 1 second when connected across a 12 V d.c supply. Determine the:

(i) current in the material;
(ii) power dissipated. (5 marks)

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