2521/105 2602/106
2601/106 2603/106
ELECTRICAL MEASUREMENTS
AND ANALOGUE ELECTRONICS I
June/July 2023
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 instrument.
*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.

Take: Electronic charge, $e = 1.602 \times 10^{-19} C$
Electron Mass, $m = 9.109 \times 10^{-31} kg$

This paper consists of 7 printed pages.
Candidates should check the question paper to ascertain that all 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) Define each of the following with respect to measurements:

   (i) resolution;
   (ii) dimensions. (2 marks)

   (b) Derive, from first principles, the dimensional equation for capacitance in c.g.s electrostatic units. (12 marks)

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

   I. electric flux density;
   II. electric field strength;
   III. magnetomotive force.

   (ii) Write down the physical equations for each of the following mechanical quantities:

   I. momentum;
   II. torque;
   III. stiffness. (6 marks)

2. (a) (i) State **two** ways of minimizing observational errors in measurements.

   (ii) With aid of a labelled diagram, describe the operation of a thermocouple ammeter. (8 marks)

(b) **Figure 1** shows a circuit diagram for measurement of resistance. The meter reads 10 A, on a 100 A range and the voltmeter reads 125 V on a 150 V range. The instrument scales are such that 0.1 of a scale can be distinguished. The constructional error of the ammeter is ±0.3% and that of the voltmeter is ±0.4%. The resistance of the ammeter is 0.25 Ω. Determine the:

(i) total systematic error in instrument readings;
(ii) measured value of resistor R;
(iii) true value of resistor R;
(iv) percentage error in the value of R. (12 marks)

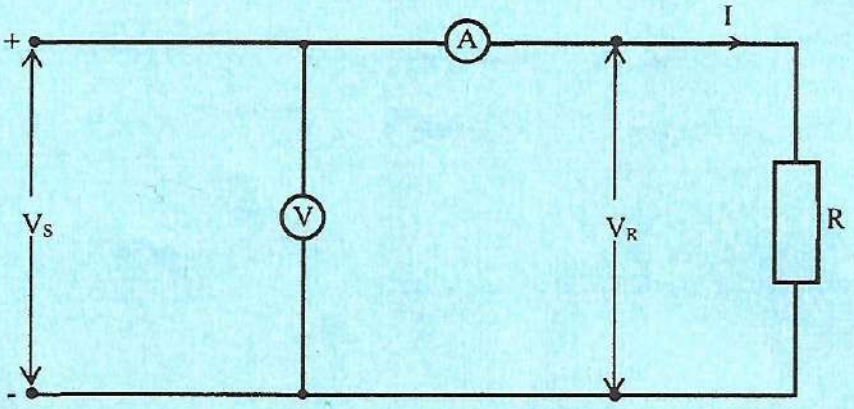

Fig. 1

3. (a) (i) State **three** factors that may affect the reliability of an engineering equipment:

(ii) Explain the effects of humidity on the performance of engineering equipment and state **two** methods of minimizing them. (8 marks)

(b) Sketch the failure rate versus time curve of a batch of electrical components and explain its shape. (6 marks)

(c) An equipment has a failure rate of 16% per 1000 hours. If it is operated for a period of 1000 hours, determine the:

(i) mean time between failures;
(ii) reliability;
(iii) probability of failure. (6 marks)

4. (a) Define each of the following with respect to engineering systems:

(i) availability;
(ii) failure rate;
(iii) mean time to repair. (3 marks)

(b) Describe preventive maintenance with respect to engineering systems. (3 marks)

(c) **Figure 2** shows a block diagram of a signal generator.

(i) Sketch the waveforms at the following test points:

I. output 1 when switch S is on CW terminal;
II. output 1 when switch S is on MOD terminal;
III. output 2.

(ii) State the fault for each of the following symptoms:

I. no output from both output terminals;
II. no output 2 but output 1 is correct. (8 marks)

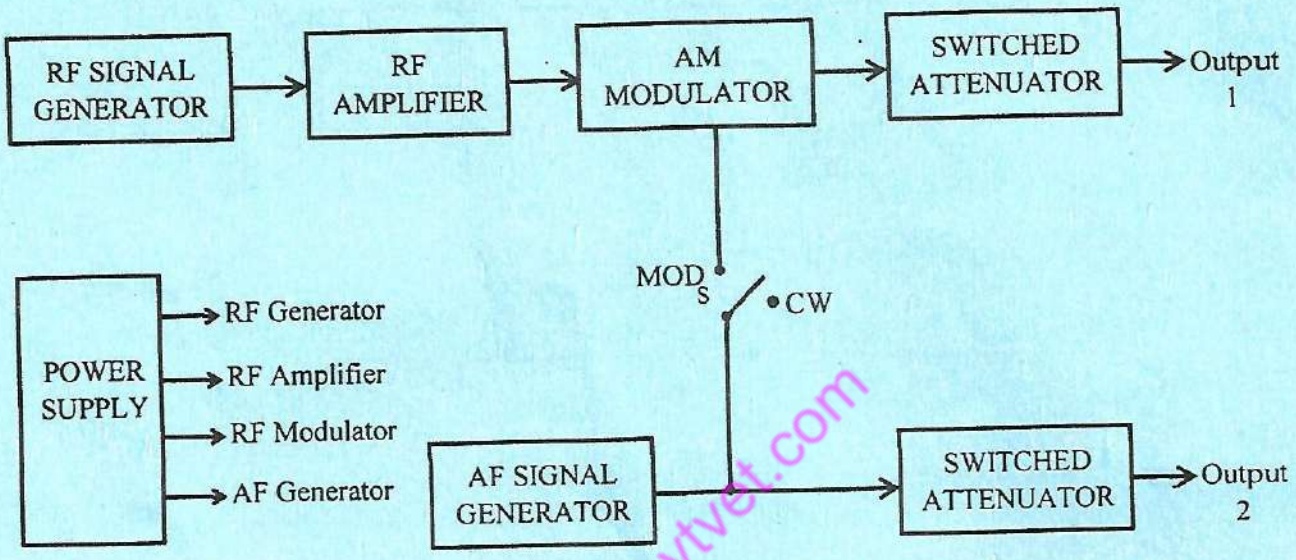

Fig. 2

(d) A system fails 4 times in a period of 1600 hours and takes 2 hours to repair. Determine the following for the system:

(i) failure rate;
(ii) mean time to repair;
(iii) maintainability for a time of 6 hours. (6 marks)

5. (a) State **three**:

(i) faults that can be revealed by visual inspection of electrical/ electronic systems;
(ii) faults that can occur in aluminium electrolytic capacitors. (6 marks)

(b) Outline the procedure of testing a diode using a digital multimeter. (6 marks)

(c) Explain each of the following printed circuit board (PCB) soldering defects:

(i) open solder joint;
(ii) cold joint. (4 marks)

(d) In the measurement of inductance of a coil using a Q-meter, resonance is obtained with a capacitor of 188 pF. The resonant frequency is 159 kHz and the Q-factor of the coil is 70. For the coil, determine the:

(i) inductance;
(ii) effective resistance. (4 marks)

SECTION B: ANALOGUE ELECTRONICS I

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

6. (a) State **three** advantages of silicon diodes over germanium diodes. (3 marks)

(b) (i) Sketch two current versus voltage (I-V) characteristic curves for a forward-biased p - n junction at temperatures T1 and T2, where T2 > T1.

(ii) Explain the effects of temperature on the curves in (b)(i). (5 marks)

(c) With aid of a labelled diagram, describe the formation of an n-type semiconductor. (6 marks)

(d) A sample of an n-type material has a resistance of 3 kΩ. It is connected across a 15 V_{dc} supply. Determine the:

(i) current in the circuit;
(ii) electrons passing a given point per second;
(iii) number of electrons passing the point in (d)(ii) in 20 ms. (6 marks)

7: (a) Define the transistor parameters represented by each of the following symbols:

(i) β

(ii) $\propto$

(iii) g_m (3 marks)

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

(c) Figure 3 shows a circuit diagram of an n-channel depletion MOSFET amplifier. The pinch-off voltage and the drain-source saturation current for the MOSFET are -5V and 4 mA respectively. Determine the:

(i) gate voltage, V_G;
(ii) gate - source voltage, V_{GS};
(iii) drain current, I_D;
(iv) drain terminal voltage, V_D;
(v) drain -source voltage, V_{DS} (10 marks)

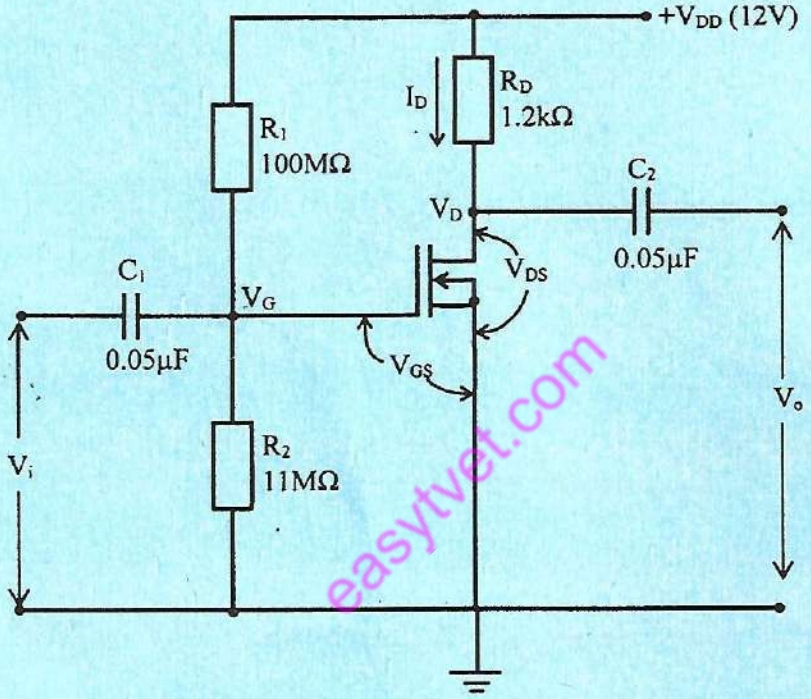

Fig. 3

8. (a) (i) State **two** advantages of full-wave rectification over half-wave rectification.

(ii) Draw a labelled block diagram of a regulated dc power supply. (6 marks)

(b) A full-wave rectifier is fed from a 240 V_{rms} / 12 V_{rms} transformer at 50 Hz. The rectifier feeds a pure resistive load of 560 Ω. Determine the:

(i) peak value of the secondary voltage;
(ii) dc load voltage;
(iii) dc load current;
(iv) ripple frequency. (8 marks)

(c) A cathode ray tube (CRT) has an accelerating potential of 2.2 kV and parallel deflecting plates 2 cm long and 5 mm apart. The screen is 50 cm from the centre of the deflecting plates. The voltage to the deflecting plates is applied through an amplifier having a gain of 150 and it causes a deflection of 4 cm on the electron beam. Determine the:

(i) deflection voltage on the deflecting plates;
(ii) voltage applied to the amplifier;
(iii) deflection sensitivity of the tube. (6 marks)

THIS IS THE LAST PRINTED PAGE.