

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.**

© 2023 The Kenya National Examinations Council

**Turn over**

## SECTION A: ELECTRICAL MEASUREMENTS

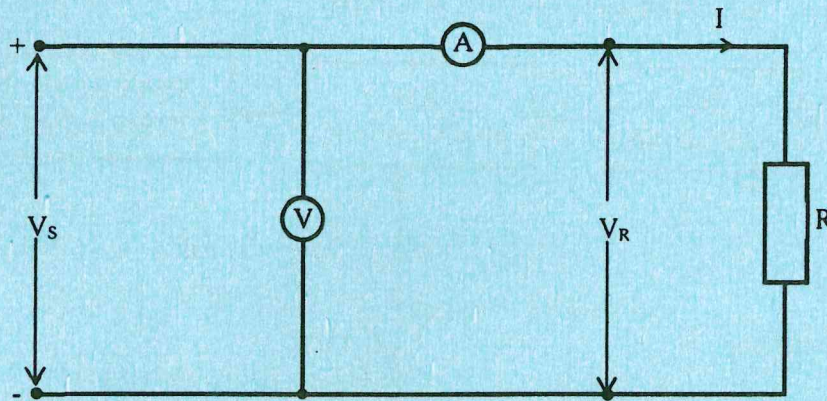
Answer **THREE** questions from this section.

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  $\pm 0.3\%$  and that of the voltmeter is  $\pm 0.4\%$ . The resistance of the ammeter is  $0.25 \Omega$ . 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.

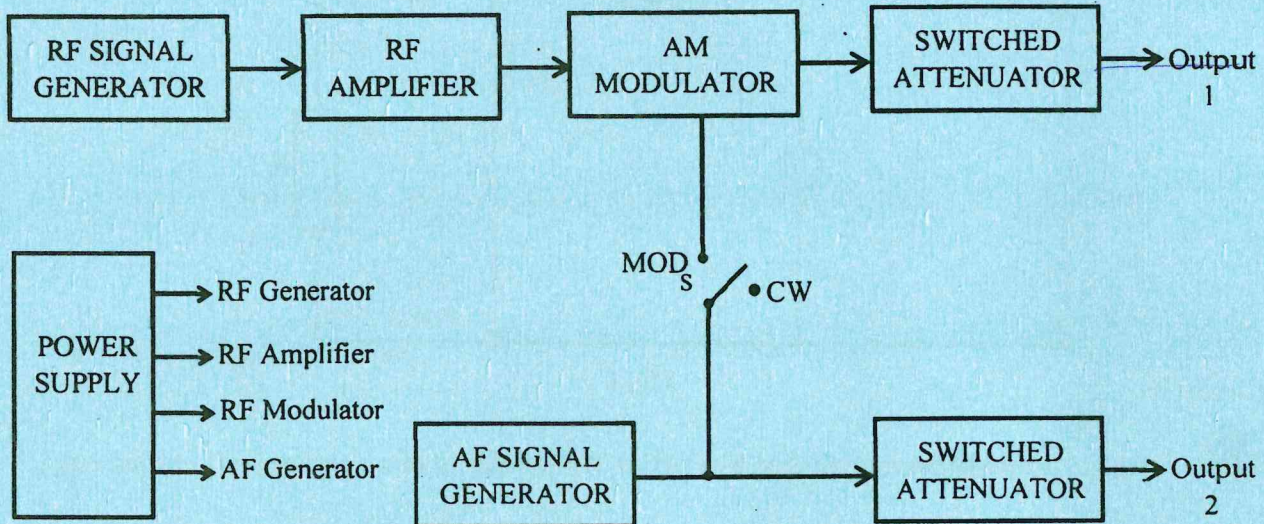
(i) Sketch the waveforms at the following test points:

- 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 k $\Omega$ . It is connected across a 15 V<sub>dc</sub> 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)  $\beta$
  - (ii)  $\alpha$
  - (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  $4\text{ mA}$  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)

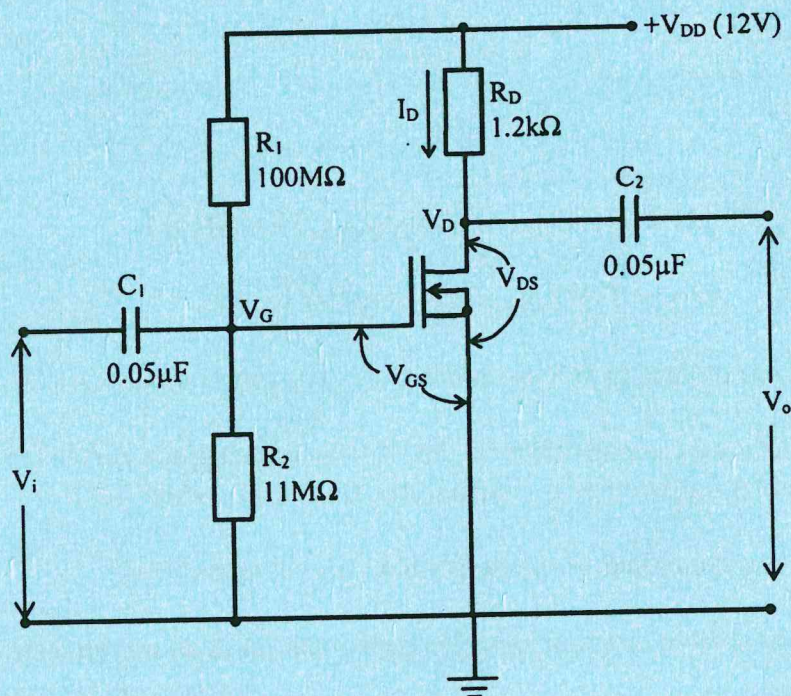


Fig. 3

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  $560 \Omega$ . 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.**