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**ELECTRICAL MEASUREMENTS  
AND ANALOGUE ELECTRONICS I**

**June/ July 2022**

**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;*

*Graph paper;*

*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 TWO questions from section B in the answer booklet.*

*All questions carry equal marks.*

*Maximum marks for each part of a question are as indicated.*

*Candidates should answer the questions in English.*

*Take: Permeability of free space,  $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$*

**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.**

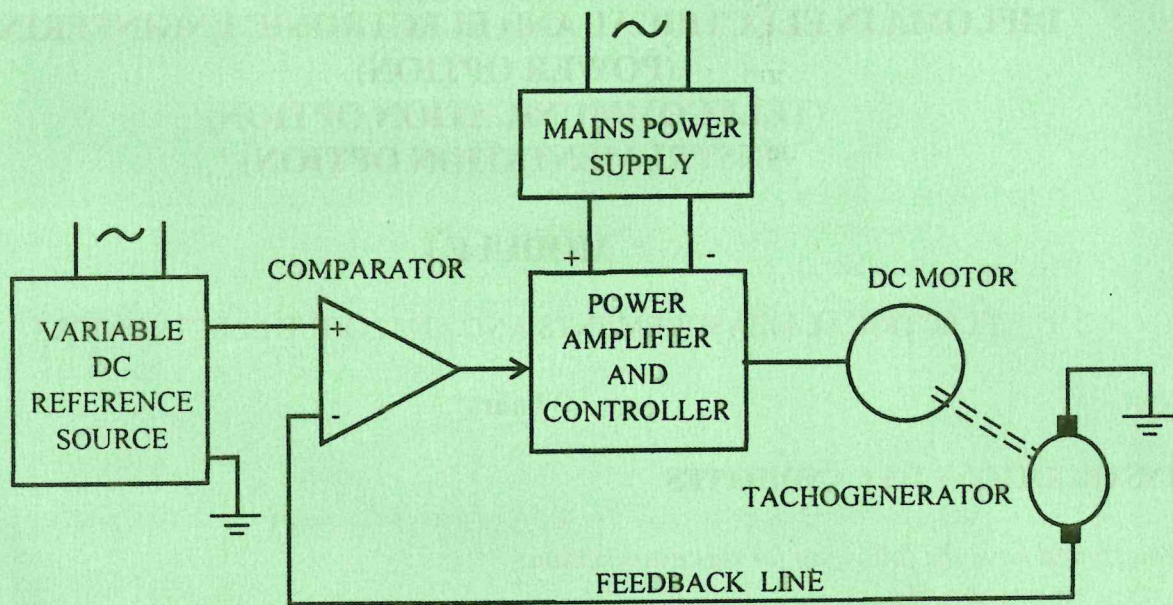


## SECTION A: ELECTRICAL MEASUREMENTS

Answer **THREE** questions from this section.

1. (a) (i) Distinguish between modifying and sustaining feedback signals.
- (ii) **Figure 1** shows a diagram for the speed control of a d.c motor.
- (I) Explain the effect of an open circuit fault in the feedback line on the speed of the motor.
- (II) Outline the procedure of locating the fault in a(ii) I and state the expected results.

(8 marks)



**Fig. 1**

- (b) State **four** elements contained in a circuit diagram that can assist in the repair and maintenance of an electrical equipment. (4 marks)
- (c) An electrical equipment has a repair rate of 0.6 and mean time between failure of 15,000 hours. Determine the:
- (i) failure rate;
- (ii) mean time to repair;
- (iii) unavailability;
- (iv) availability.

(8 marks)

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2. (a) State **three** factors that can introduce errors in power measurements when using wattmeters. (3 marks)
- (b) An amplitude modulated signal has a maximum amplitude of  $V_{\max}$  and a minimum amplitude of  $V_{\min}$ .
- (i) Obtain the expression of the modulation index in terms of the carrier voltage,  $V_c$  and the modulating signal voltage,  $V_m$ .
- (ii) Sketch the waveform of the signal in b(i). (7 marks)
- (c) A search coil has 500 turns and a mean area of  $450 \text{ mm}^2$ . The coil is placed at the centre of a solenoid 1.5 m long, wound with 700 turns. When a current of 5.5 A is reversed, there is a deflection of 26 scale divisions on a flux meter connected to the search coil. Determine the flux linkages per scale division. (10 marks)
3. (a) Define each of the following failures with respect to an electrical equipment:
- (i) misuse;
- (ii) sudden;
- (iii) partial. (3 marks)
- (b) Sketch, on the same axes, the curves of cost against reliability for the following and explain their shape:
- (i) production;
- (ii) design and development;
- (iii) maintenance and repair. (7 marks)



(c) **Table 1** shows the data of an electronic equipment operated for a period of 1,000 hours. Determine the:

- (i) equipment failure rate;
- (ii) mean time between failure;
- (iii) reliability;
- (iv) probability of failure.

(10 marks)

**Table 1**

COMPONENTS	QUANTITY (n)	FAILURE RATE ( $\lambda$ ) % per 1,000 hours	WEIGHTING FACTOR (w)
Silicon transistors	40	0.01	1.0
Signal diodes	100	0.01	1.0
Rectifier diodes	10	0.01	1.5
Carbon resistors	100	0.005	1.0
Metal oxide resistors	100	0.005	1.5
Ceramic capacitors	50	0.025	1.0
Electrolytic capacitors	20	0.2	3.0
Soldered connections	500	0.001	-

4. (a) Explain each of the following standards:

- (i) working standards;
- (ii) international standard.

(4 marks)

(b) A standard cell has a voltage rating of 1.018500 V and an internal resistance of 500  $\Omega$ . The insulation resistance between its terminals is 5 M $\Omega$ . Determine the:

- (i) current drain due to the insulation resistance;
- (ii) voltage drop due to the resistance of the cell;
- (iii) terminal voltage.

(6 marks)

(c) (i) The expression for torque, T, of a machine is written as  $T = kM^a E^b Z^c$ , where k = a constant, M = mutual inductance, E = applied voltage and Z = impedance. Taking the dimensional equation for  $T = [ML^2T^{-2}]$ ,  $M = [\mu L]$ ,  $E = [\mu^{\frac{1}{2}} M^{\frac{1}{2}} L^{\frac{3}{2}} T^{-2}]$  and  $Z = [\mu L T^{-1}]$ , determine the values of a, b and c.

(ii) State the SI units for each of the following quantities:

- (I) temperature;
- (II) luminous intensity.

(10 marks)

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5. (a) (i) State **three** advantages of oscilloscopes over multi-meters when used in fault diagnosis.
- (ii) Outline the steps taken in displaying a signal on an oscilloscope.
- (9 marks)

(b) State **two** possible causes for each of the following faults in a d.c motor:

- (i) motor fails to start;
- (ii) motor runs but loses power.

(4 marks)

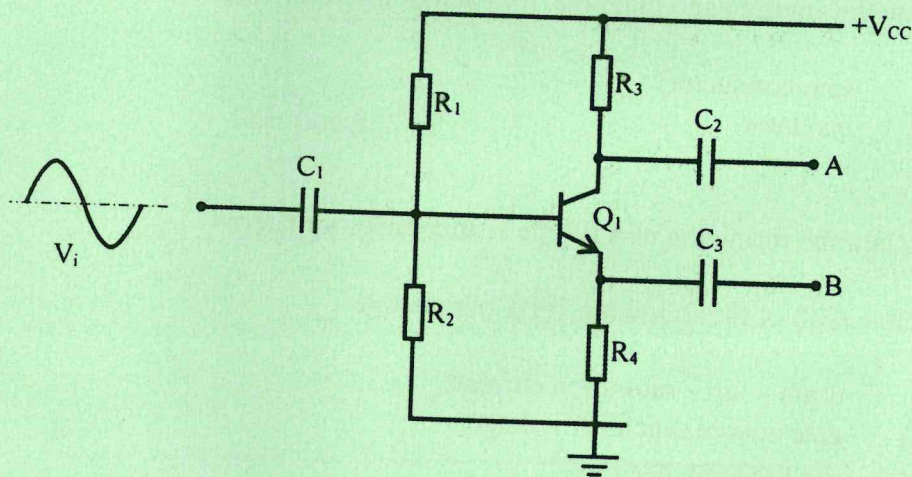
(c) **Figure 2** shows a circuit diagram of an amplifier.

(i) Sketch the output waveforms at terminals A and B.

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

- (I)  $C_2$  open circuit;
- (II)  $R_2$  open circuit.
- (III) base-emitter junction if  $Q_1$  short circuit.

(7 marks)



**Fig. 2**

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## SECTION B: ANALOGUE ELECTRONICS I

Answer *TWO* questions from this section.

6. (a) State **three** areas of application of semiconductor diodes. (3 marks)
- (b) Table 2 shows the data of a p-n junction diode where  $V_F$  and  $I_F$  are the forward voltages and currents respectively.
- (i) Plot the characteristic curve on the graph paper provided.
- (ii) Estimate the forward resistance of the diode.
- (iii) Determine the power dissipated at an operating voltage of 4.5 V. (7 marks)

**Table 2**

$V_F$ (V)	0	1	2	3	4	5	6
$I_F$ (mA)	0	0.2	1.0	3.2	6.2	10.2	17.0

- (c) Draw the energy band diagrams for each of the following materials:
- (i) semiconductor;
- (ii) insulator. (6 marks)
- (d) Explain the formation of a P-type semiconductor material. (4 marks)
7. (a) Define each of the following JFET parameters:
- (i) drain-source saturation current;
- (ii) gate-source pinch-off voltage;
- (iii) drain-source resistance. (3 marks)



(b) In an n-channel JFET, a change in gate-source voltage ( $V_{gs}$ ) from 0 V to -3 V causes a corresponding change in drain current ( $I_d$ ) from 10.2 mA to 0.4 mA at a drain-source voltage ( $V_{ds}$ ) of 12 V. A change in  $V_{ds}$  from 0 V to 24 V causes a corresponding change in  $I_d$  from 0 mA to 3.1 mA at  $V_{gs} = -2$  V. Determine the:

- (i) drain-source resistance;
- (ii) mutual conductance;
- (iii) amplification factor.

(6 marks)

(c) Draw a circuit diagram showing the common-base configuration of a transistor amplifier.

(3 marks)

(d) **Figure 3** shows a circuit diagram of an emitter-follower. Taking  $\beta$  of the transistor as 45 and  $V_{be}$  as 0.7 V, determine the:

- (i) base current,  $I_b$ ;
- (ii) emitter current,  $I_e$ ;
- (iii) collector-emitter voltage,  $V_{ce}$ ;
- (iv) collector voltage,  $V_c$ .

(8 marks)

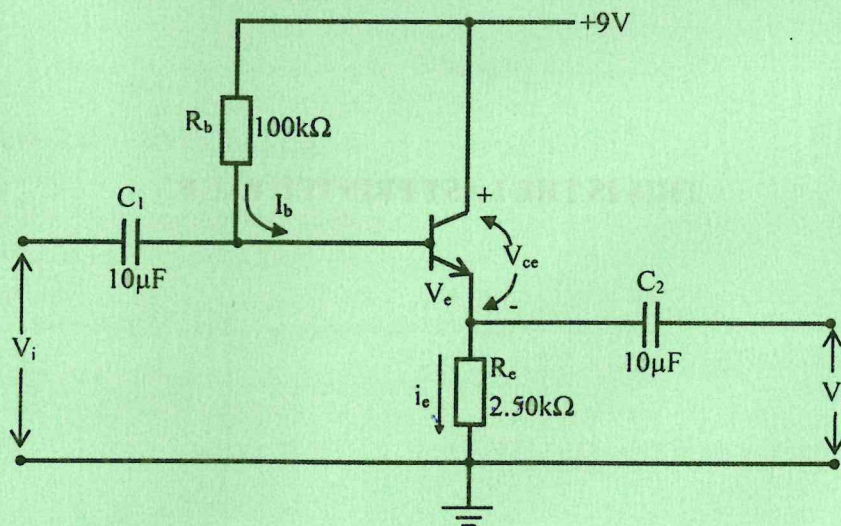


Fig. 3

8. (a) (i) Define each of the following with respect to d.c power supplies:

- (I) ripple;
- (II) peak inverse (or reverse) voltage.

(2 marks)

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- (b) A single-phase full-wave rectifier is supplied from a transformer having a turns ratio of 4:1 and connected to a pure resistive load of  $2\text{ k}\Omega$ . The main power supply is 240 Vrms, 50 Hz. Neglecting the diode volt drops, determine the:
- (i) peak voltage of the transformer secondary;
  - (ii) d.c voltage of the rectifier output;
  - (iii) d.c load current;
  - (iv) frequency of the ripple voltage.
- (8 marks)
- (c) With aid of a labelled diagram, describe electrostatic deflection of an electron beam.
- (6 marks)
- (d) (i) Sketch the waveform of the timebase voltage produced by the timebase generator in a cathode-ray tube.
- (ii) Explain the function of the voltage in d(i).
- (4 marks)

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