2521/105, 2602/106
2601/106, 2603/106
ELECTRICAL MEASUREMENTS AND
ANALOGUE ELECTRONICS I
June/July 2017
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 table/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 all questions in English.

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.

SECTION A: ELECTRICAL MEASUREMENTS

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

1. (a) (i) Describe the following standards with respect to measurements:

(I) secondary;

(II) working.

(ii) A standard cell has a voltage rating of 1.018500 V and internal resistance of 500Ω. If the insulation resistance between its terminals is 5 MΩ, determine the:

(I) current drain due to insulation resistance;

(II) difference between the rated voltage and the drop due to internal resistance.

(9 marks)

(b) Derive the dimensional equation of "work done" in MLT system of units. (5 marks)

(c) A voltmeter having a sensitivity of 1,000 Ω/V reads 100V on its 150V scale when connected across an unknown resistor in series with a milliammeter. Neglecting the milliammeter resistance, determine the percentage error due to the loading effect of the voltmeter when the milliammeter reads 5 mA. (6 marks)

2. (a) (i) State **one** source of error in wattmeters when used in measurements.

(ii) With the aid of a labelled block diagram, describe the heterodyne method of frequency measurement.

(7 marks)

(b) A solenoid, 1.2 m long, is uniformly wound with 800 turns. A search coil of mean diameter 30 mm, wound with 50 turns, is placed at the centre of the solenoid and connected to a ballistic galvanometer. The total resistance of the search-coil circuit is 2000Ω. When a current of 5A through the solenoid is reversed, the deflection on the galvanometer scale is 85 divisions.
Taking $\mu_0 = 4\pi \times 10^{-7}$ H/m, determine the ballistic constant of the galvanometer in coulombs/unit deflection.

(13 marks)

3. (a) (i) Define reliability with respect to engineering systems.

(ii) Sketch, on the same axis, the curves showing the manufacturing cost against reliability and explain the shape of each curve.

(8 marks)

(b) Outline the procedure of assessing the reliability of an equipment. (8 marks)

(c) In a test of 400 diodes, 5 failed over a 1,000 hour period. For the diodes, determine the:

(i) failure rate;

(ii) mean time to fail.

(4 marks)

4. (a) (i) State any **two** possible causes of open circuit fault in carbon composition resistors.

(ii) Figure 1 shows a schematic block diagram of a d.c motor speed control system. Explain the effect of an open circuit fault in the feedback line and how it can be verified.

(7 marks)

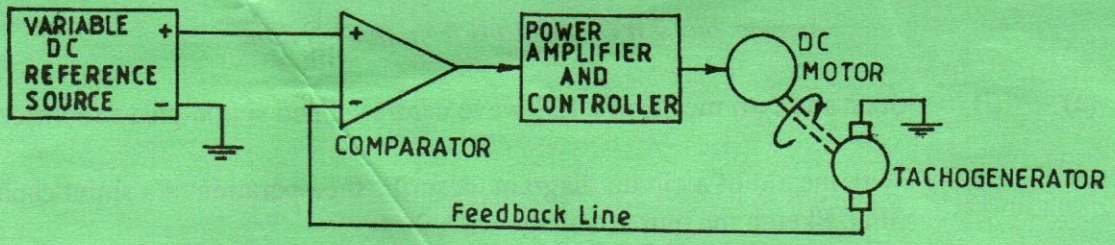

Fig. 1

(b) With the aid of a labelled block diagram incorporating a signal generator and an oscilloscope, describe a test to determine the gain of a faulty audio amplifier.

(7 marks)

(c) In an electrical system, the probability (P_t) of the system being returned to working condition within a time of 4 hours is 86.5%.
Determine the:

(i) mean time to repair;

(ii) failure rate.

(6 marks)

5. (a) (i) Distinguish between instrumental errors and environmental errors with respect to measurements.

(ii) With the aid of a circuit diagram, describe how a full-wave rectifier instrument is used to measure the r.m.s value of an a.c voltage.

(9 marks)

(b) (i) With the aid of a phasor diagram, show that the power measured by the two-wattmeter method in a 3-phase system gives the total power in the system. Assume the wattmeters are connected in the red and blue phases.

(ii) In the measurement in b(i), the readings on each wattmeter is 5.2 kW and −1.7 kW. Determine the:

(I) total power;

(II) power factor.

(11 marks)

SECTION B: ANALOGUE ELECTRONICS I

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

6. (a) (i) State any **two** merits of a full-wave centre-tapped single-phase rectifier.

(ii) With the aid of a circuit diagram, describe the operation of a shunt capacitor filter. Sketch the output voltage waveform.

(10 marks)

(b) Show that the r.m.s. value, $V_{r(rms)}$, of the a.c. component of the rectified voltage from a full-wave diode rectifier equals $0.308\ V_{peak}$. (6 marks)

(c) A series dc-to-ac inverter has an inductor of 10 mH, a capacitor of 47 μF and a load resistor of 5Ω. Determine the:

(i) resonant frequency;

(ii) time period of oscillations

(4 marks)

7. (a) (i) Define the following JFET parameters:

(I) drain-source saturation current;

(II) gate-source cutoff (pinch-off) voltage.

(ii) With the aid of a labelled construction diagram, describe the operation of an n-channel depletion MOSFET and sketch its output characteristic curves.

(9 marks)

(b) Figure 2 shows a circuit diagram of a transistor amplifier. For stability reasons, the current through R_2 must be ten times the base current. Taking $\beta = 100$, $V_{BE} = 0.7V$, $Vc = 8V$, $V_E = 2V$ and $Ic = 1mA$, determine the value of the bias resistors R_1, R_2, R_3 and R_4.

(11 marks)

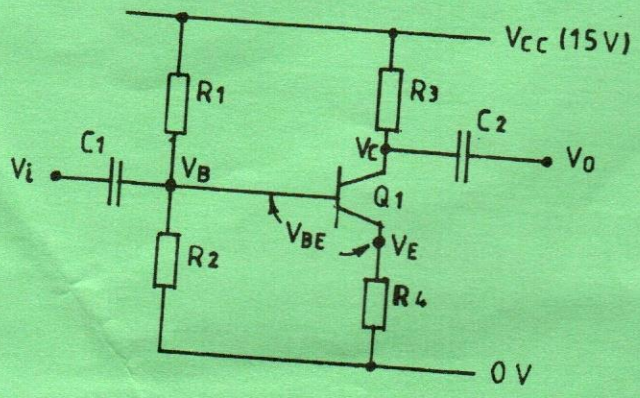

Fig. 2

8. (a) (i) State any **two** of Bohr's postulates with respect to the energy levels of an electron.

(ii) With the aid of a covalent bond diagram of an intrinsic semiconductor, explain how a hole takes part in conduction.

(8 marks)

(b) Sketch the characteristic curve of a p-n junction diode and explain its shape. (6 marks)

(c) An electrostatic CRO has deflection plates of length, $l = 2$ cm and distance between them, $d = 3$ mm. It is operated at an anode voltage, $V_a = 2$ kV and deflection potential, $V_d = 150$ V. Taking electron charge , $e = 1.602 \times 10^{-19}$C and electron mass, $m = 9.109 \times 10^{-31}$ kg, determine the:

(i) velocity of the electron beam;

(ii) transit time through the plates;

(iii) electric field intensity between the plates.

(6 marks)

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