2521/105 2602/106
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ELECTRICAL MEASUREMENTS
AND ANALOGUE ELECTRONICS I
March/April 2024
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.

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) (i) State **two** sources of errors in Q-meter measurements.

(ii) With aid of a circuit diagram describe the measurement of the Q- factor of a coil using a Q-meter.

(10 marks)

(b) (i) State three detectors used in a.c bridges.

(ii) Figure 1 shows a circuit diagram of Maxwell's inductance bridge. Obtain the expressions for R_1 and L_1 in terms of other circuit components under balance condition. (10 marks)

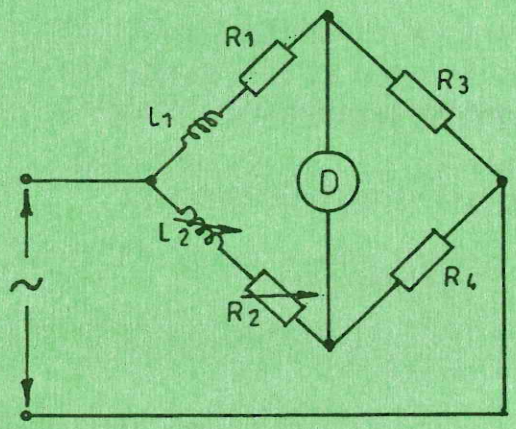

Fig. 1

2. (a) (i) Define each of the following types of failures in electrical/electronic equipment:

(I) Catastrophic;
(II) Partial;
(III) Sudden.

(ii) State **three** benefits of carrying out maintenance of electrical/electronic equipment: (6 marks)

(b) In a working period of 100 hours, an electronic equipment fails 2 times. The total time taken for repair in the same period is 3 hours. Determine the:

(i) mean time to repair;
(ii) mean time between failure;
(iii) failure rate;
(iv) availability. (8 marks)

(c) (i) The reliability (R) of an equipment is given by the expression $R=\ell^{-\lambda t}$, where λ = *failure rate and* t = *operating time*. Obtain the expression for the unreliability (Q) of the equipment.

(ii) Sketch, on the same axes, curves for reliability and unreliability of an equipment.

(6 marks)

3. (a) Derive, from first principles, the dimensional equations for the following mechanical quantities using MKS system of measurements:

(i) force;
(ii) energy.

(8 marks)

(b) The resistance (R) of a conductor is given by the expression $R = \frac{\rho l}{a}$, where ρ = resistivity, l = length and a=cross-section area.
Derive the dimensional equation of resistivity using the *LMTI* system of dimensions.

(6 marks)

(c) A sinusoidal voltage is observed on an oscilloscope as having a peak-to-peak amplitude of 8.4 cm. The vertical sensitivity setting of the oscilloscope is 5V/cm. For the voltage, determine the:

(i) peak-to-peak value;
(ii) amplitude;
(iii) r.m.s value.

(6 marks)

4. (a) State **two** possible causes of faults in:

(i) wire-wound resistors;
(ii) aluminium electrolytic capacitors.

(4 marks)

(b) Figure 2 shows a series chain of blocks making up an electronic system. It is assumed that block 2 is faulty.

(i) Using half-split method, describe how to identify the faulty block.
(ii) State the assumptions made in the method in b(i).

(6 marks)

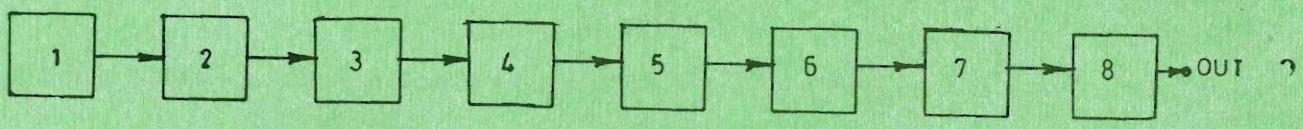

Fig. 2

(c) An audio frequency power amplifier is to be tested after repair using an audio frequency signal generator and an oscilloscope:

(i) Draw a labelled block diagram for the test set-up;
(ii) Describe the test for the output power from the set-up in c(i).

(7 marks)

(d) State **three** test equipment used in the maintenance of digital logic circuits.

(3 marks)

5. (a) (i) State **three** methods of minimizing instrument errors in wattmeters during power measurements.

(ii) Figure 3 shows a circuit diagram of the two-wattmeter method of power measurement in a 3-phase balanced load. Show that the total power, P_T. from this measurement is given by the expression, $P_T = \sqrt{3}\, V_L I_L \cos\phi$, where V_L= line voltage, I_L= line current and ϕ=phase angle between V_L and I_L.

(11 marks)

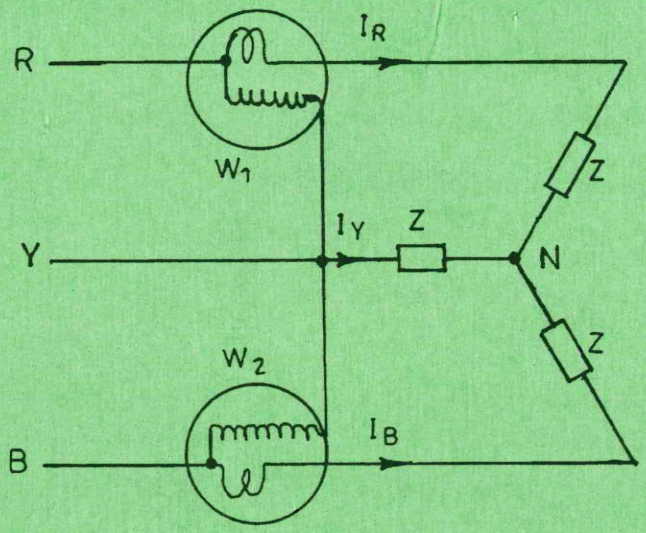

Fig. 3

(b) (i) Distinguish between primary fundamental/units and auxiliary fundamental units.

(ii) Describe 'standard' with respect to measurements.

(5 marks)

(c) A standard cell of internal resistance 500 Ω has a voltage rating of 1.018500 V. The insulation resistance between its terminals is 5M Ω. Determine the:

(i) current drain due to the insulation resistance;
(ii) internal voltage drop.

(4 marks)

SECTION B: ANALOGUE ELECTRONICS I

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

6. (a) (i) State **two** ways of ionizing an atom;
(ii) Distinguish between positive and negative ions.

(4 marks)

(b) (i) Draw and label the energy band diagram of a semiconductor material;
(ii) Define each band in b(i).

(6 marks)

(c) With aid of a labelled diagram, describe the formation of a P-type semiconductor.

(6 marks)

(d) Sketch, on the same axes, the forward and reverse characteristic curves of a *p-n* semiconductor diode.

(4 marks)

7 (a) Figure 4 shows a basic block diagram of a cathode-ray oscilloscope.

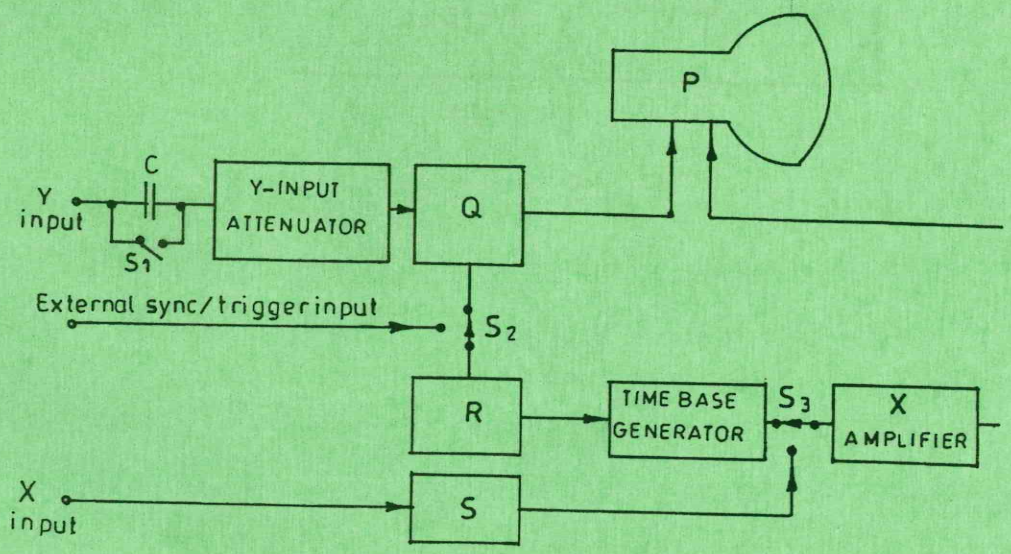

Fig. 4

(i) Identify the blocks marked **P**, **Q**, **R**, and **S**.

(ii) Explain the function of the capacitor **C** and switch S_1 combination.

(iii) Sketch the waveform at the output of the timebase generator.

(10 marks

(b) Figure 5 shows a circuit diagram of a common-collector amplifier. Assuming $V_{be} = 0.7V$ and $I_E \simeq I_C$, determine the following bias quantities;

(i) V_B;
(ii) V_E;
(iii) I_E;
(iv) V_C;
(v) V_{CE}.

(10 marks)

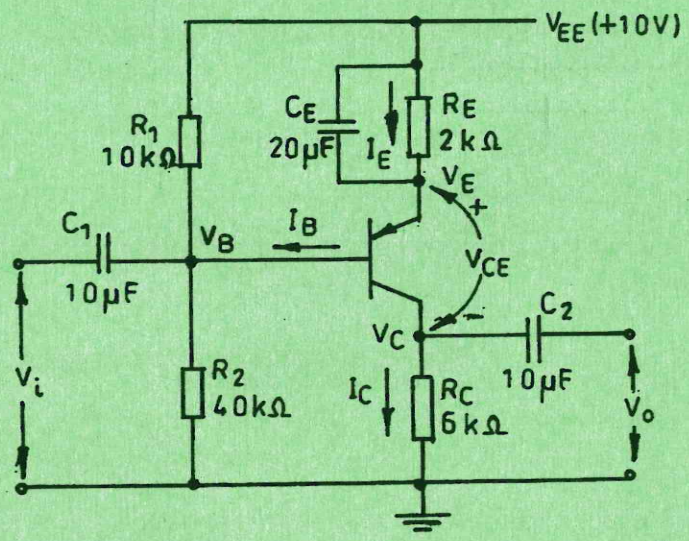

Fig.5

8. (a) Define each of the following JFET parameters:

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

(2 marks)

(b) Table 1 shows the data for an n-channel JFET. Use the data in the table to determine the following devise parameters:

(i) mutual conductance at V_{DS}= 5V;
(ii) drain -source resistance at V_{GS}= -3V;
(iii) amplification factor.

(6 marks)

Table 1

V_{DS} (V)	I_D (mA)		
	$V_{GS} = -2V$	$V_{GS} = -3V$	$V_{GS} = -4V$
1	3.1	4.6	6.6
3	3.5	5.1	6.9
5	3.9	5.6	7.2
7	4.3	6.1	7.8
9	4.7	6.6	8.4

(c) With aid of a circuit diagram, describe the operation of a full-wave voltage double.

(6 marks)

(d) (i) A d.c power supply has an output of 60V at no load and 56V at full load. The rms value of the ripple voltage at no load is 1.5V. Determine the:

(I) Voltage regulation;;

(II) Percent ripple.;

(ii) Sketch the voltage regulation curves for the power supply in d(i).

(6 marks)

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