2521/105 2602/106
2601/106 2603/106
ELECTRICAL MEASUREMENTS
AND ANALOGUE ELECTRONICS I
June/July 2021
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;*
- *Drawing instruments;*
- *Scientific calculator/mathematical tables.*

*This paper consists of **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 6 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.*

(a) (i) State **one** advantage and **one** disadvantage of indirect - contact as compared to direct-contact thermocouple ammeters.

(ii) With the aid of a circuit diagram, describe the operation of the direct-contact thermocouple ammeter. (8 marks)

(b) Figure 1 shows a circuit diagram of a permeameter used to test a ferro-magnetic specimen. The testing is done by reversing the current in the magnetising winding resulting in a deflection of 100 divisions on the galvanometer connected to coil X and 10 divisions on the galvanometer connected to coil Y. Each of the galvanometers have a constant of 25×10^{-6} weber-turn per scale division. Coil X has 100 turns and effective area of $50 \times 10^{-6}\,m^2$ while coil Y has 10,000 turns and effective area of $5 \times 10^{-6}\,m^2$. Taking permeability of free space, $\mu o = 4\pi \times 10^{-7}$ H/m, determine the:

(i) flux density in the specimen;
(ii) flux density in the air;
(iii) magnetising force;
(iv) relative permeability of the specimen. (8 marks)

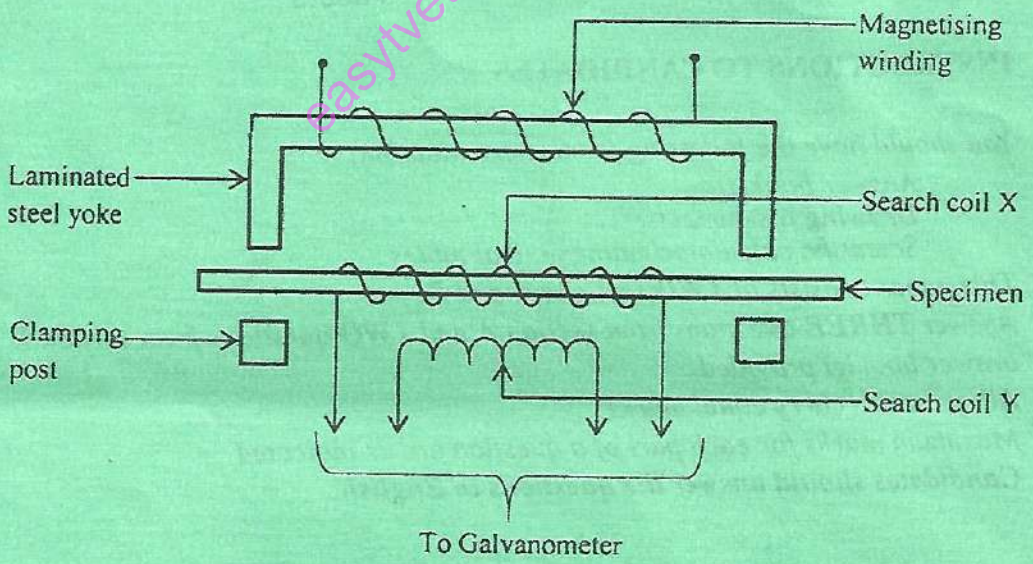

Fig. 1

(c) A voltmeter having a range of 0-150 V has a guaranteed accuracy of 1 percent of full-scale reading. For a reading of 75V, determine the percentage limiting error of the instrument. (4 marks)

2. (a) (i) Define redundancy with respect to reliability.

(ii) State:

I. **Two** effects that leads to degraded reliability due to mechanical vibrations and shock.

II. **Two** ways of minimizing the effects in (I). (5 marks)

(b) List **five** features that a designer should consider during design so as to make the availability of an equipment as high as possible. (5 marks)

(c) Table 1 shows data for various components in an electronic equipment. The equipment is put in operation for a period of 1,000 hours. Determine the:
(i) Overall failure rate for each type of component;
(ii) equipment failure rate;
(iii) Mean time between failure of the equipment;
(iv) unreliability of the equipment. (10 marks)

Table 1

Component	Quantity (n)	Failure rate (λ) percent per 1000 hours	Weighting factor (w)
Resistors	200	0.004	1.5
Transistors	300	0.05	1.0
Thyristors	4	0.5	1.2
Capacitors	20	0.02	3.0
ICs	290	0.02	1.0
Connections	1000	0.001	-

3. (a) With the aid of a labelled diagram, explain the measurement of depth of modulation of an amplitude modulated wave using an oscillaoscope with the timebase switched off. Assume sinusoidal signals. (7 marks)

(b) (i) State **three** desirable characteristics of shunts used in extending the range of a meter.
(ii) A moving coil instrument has a coil of resistance 4Ω and gives a full-scale deflection with a current of 20 mA. Determine the values of resistors required so that the instrument can read upto:

I. 1A;
II. 15 V. (7 marks)

(c) A sinusoidal source feeds an a.c. circuit with the current lagging the voltage by an angle ϕ. Show that the average power over one cycle in the a.c circuit is equal to the wattmeter reading. (6 marks)

4. (a) (i) Define each of the following with respect to electrical measurements:

I. standard;
II. derived unit.

(ii) Describe each of the following standards of measurement:

I. international;
II. primary. (8 marks)

(b) Using LMTI system of dimensions, prove that the equation e = Blv is dimensionally correct, where e = e.m.f induced in a conductor, B = flux density, l = effective length of conductor and V = velocity at which the conductor cuts the magnetic field. (9 marks)

(c) Determine the mechanical quantity represented by the dimensional equation. (MLT^{-1}) (3 marks)

5. (a) State **three** service actions to take during routine maintenance of an electrical/electronic system. (3 marks)

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

(i) high bearing temperature;
(ii) excessive sparking at motor commutator;
(iii) rapid wear of brushes. (6 marks)

(c) Figure 2 shows a circuit diagram of a regulated d.c power supply. State the effects of each of the following faults:

(i) diode D1 open circuit;
(ii) capacitor C1 short circuit;
(iii) terminal 3 of the IC regulator open to ground;
(iv) capacitor C2 open circuit. (8 marks)

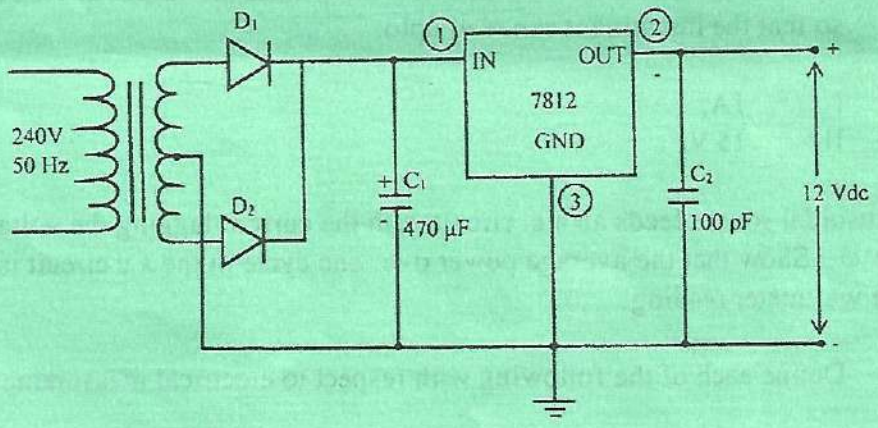

Fig. 2

(d) The repair rate of an electrical equipment is 0.5. Determine the mean time to repair (MTTR) of the equipment. (3 marks)

SECTION B: ANALOGUE ELECTRONICS I

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

6. (a) (i) Define each of the following with respect to semi conductors:

I. hole;
II. forbidden gap;
III. dour atom.

(ii) Explain avalanche breakdown with respect to p–n junctions. (7 marks)

(b) With the aid of a labelled diagram, explain the structure of an atom. (7 marks)

(c) Table 2 shows the data for a semiconductor diode.
(i) Draw the graph of current against voltage.
(ii) Determine the forward resistance of the diode. (6 marks)

Table 2

Voltage (V)	0.1	0.2	0.3	0.4	0.5
Current(mA)	0.25	0.5	1.0	3.0	8.0

7. (a) (i) State the function of each of the following parts of a dc power supply unit:

I. filter;
II. transformer.

(ii) With the aid of a circuit diagram, describe the operation of a Zener diode voltage regulator. (8 marks)

(b) A d.c power supply unit provides an output of 60 V at no load and 56V at full load. The ripple component of the output voltage is 1.25 V rms.
Determine the percentage:

(i) voltage regulation;
(ii) ripple. (4 marks)

(c) An electron released from the cathode CRT is accelerated to the anode by an accelerating potential of 2 kV in a time of 0.25 μS. Taking the mass of electron, $= 9.1 \times 10^{-31}$ kg and electronic charge, $e = 1.6 \times 10^{-19}$C, determine the:
(i) Velocity of the electron;
(ii) acceleration of the electron;
(iii) Loss in potential energy;
(iv) gain in kinetic energy. (8 marks)

8. (a) State **two** disadvantages of field effect transistors as compared to bipolar junction transistors. (2 marks)

(b) With the aid of a labelled construction diagram, describe the operation of a p-channel junction field effect transistor. (8 marks)

(c) Figure 3 shows a circuit diagram, of a common emitter amplifier. Taking Vbe = 0.7V and $I_C = I_E$, determine the following bias voltages and currents:

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

(10 marks)

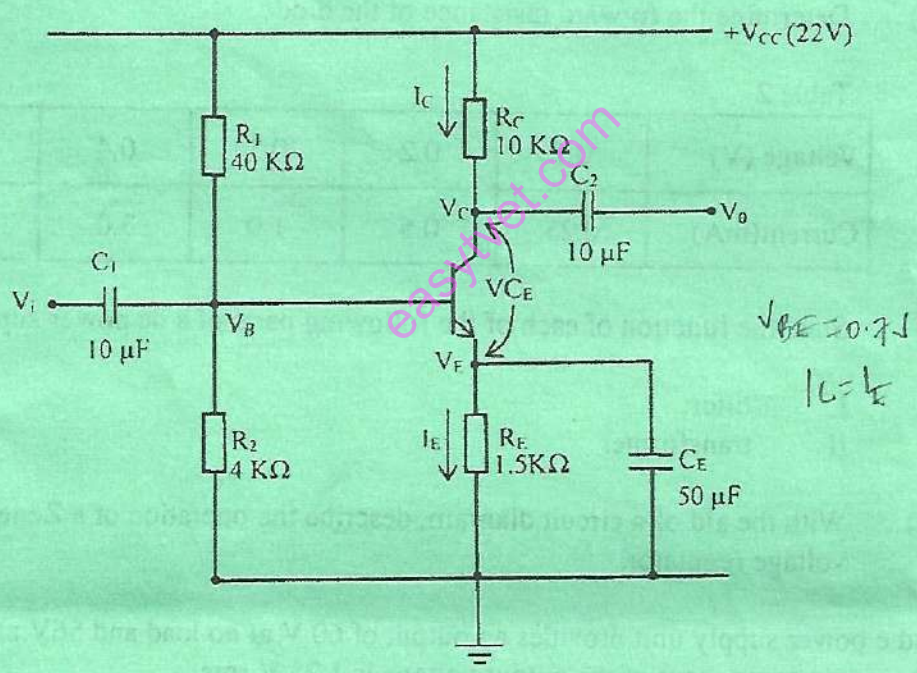

Fig. 3

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