2603/205
INSTRUMENTATION SYSTEMS AND
INDUSTRIAL MEASUREMENT I
June/July 2016
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING (INSTRUMENTATION OPTION) MODULE II

INSTRUMENTATION SYSTEMS AND INDUSTRIAL MEASUREMENT I

3 hours

INSTRUCTIONS TO CANDIDATES

You should have an electronic calculator/mathematical tables for this examination.
*This paper consists **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 shown.
Candidates should answer the 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: INSTRUMENTATION SYSTEMS

Answer any THREE questions in this section.

1. (a) Define each of the following with respect to measuring instruments:

(i) dynamic error;
(ii) measuring lag;
(iii) precision. (3 marks)

(b) (i) Figure 1 shows a three input operational amplifier circuit. Obtain the expression of the output voltage Vo in terms of the input voltages.

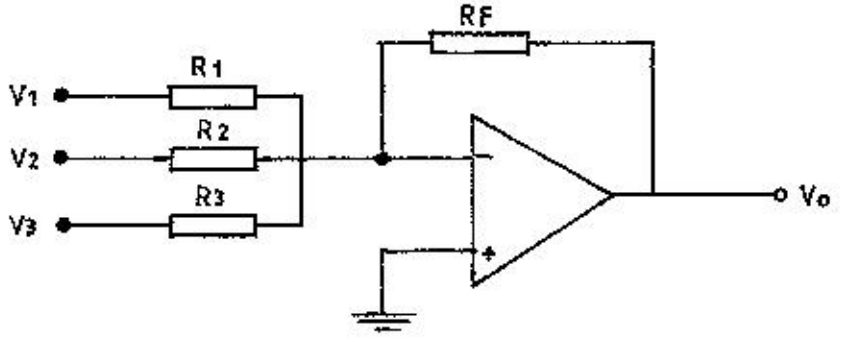

Fig. 1

(ii) State any **three** types of input circuits used for signal conditioning. (9 marks)

(c) Figure 2 shows a front panel of a signal generator with its operating knobs. Explain the function of the following knobs:

(i) frequency knob;
(ii) wave shape selection. (4 marks)

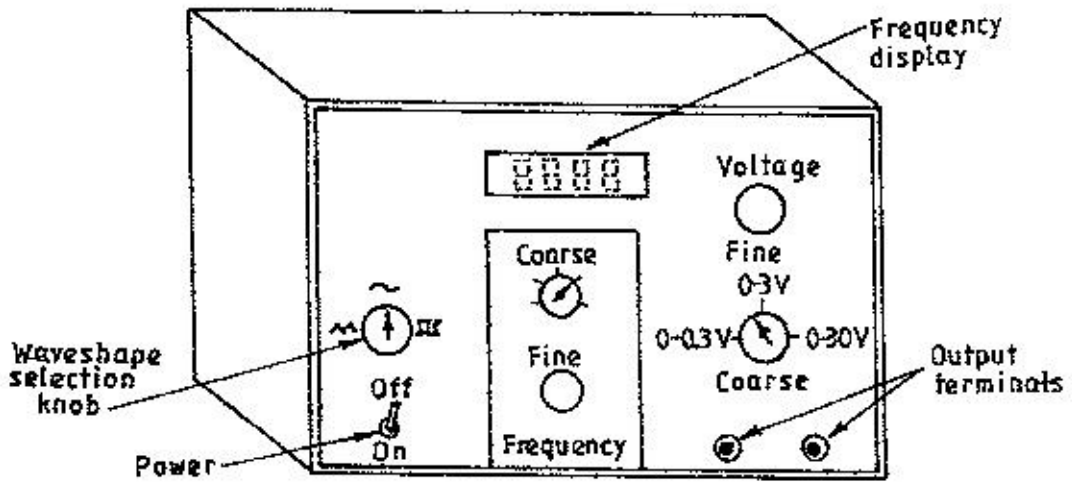

Fig. 2

(d) A step input of 5 A is applied to an ammeter. The pointer swings to a current of 5.18 A and finally comes to rest at 5.02 A. Determine the:

(i) overshoot of the reading as a percentage of the final reading;
(ii) percentage error in the reading. (4 marks)

2. (a) Distinguish between active and passive transducers. (2 marks)

(b) With the aid of a labelled diagram, explain the principle of operation of electromagnetic flow meter. (7 marks)

(c) Figure 3 shows a gray code disc for measuring angular displacement; where the inner track corresponds to the most significant bit (MSB).

(i) State **one** advantage of gray code over straight binary disc in measurement.
(ii) Derive the truth table of the gray code disc. (9 marks)

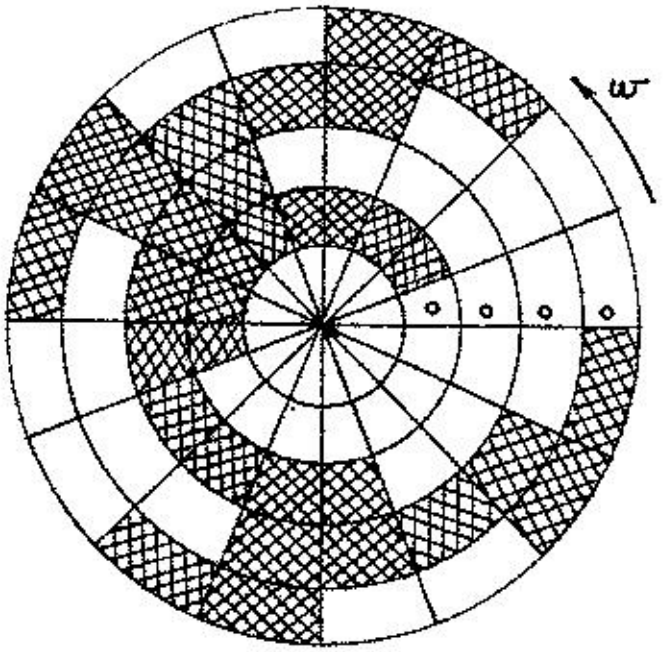

Fig. 3

(d) Sketch a labelled diagram of a flapper-Nozzle pneumatic transducer. (2 marks)

3. (a) (i) State any **three** properties of an instrumentation amplifier.
(ii) With the aid of a circuit diagram, describe the operation of an instrumentation amplifier. (9 marks)

(b) Sketch the ideal response curves for each of the following filters:

(i) band stop;
(ii) high pass. (4 marks)

(c) Sketch the following waveforms as applied in amplitude modulation, assuming sinusoidal input signal.

(i) carrier signal;
(ii) modulating signal;
(iii) modulated output. (7 marks)

4. (a) With the aid of a labelled block schematic diagram, explain the operation of voltage to frequency converter. (7 marks)

(b) A 7 - bit weighted resistor D/A converter has a resistance of 300 k Ω in LSB position. The reference voltage is 12 V. The resistive network is connected to an op-amp with 6 k Ω feedback resistor.
Determine:
(i) the resistance in MSB;
(ii) the smallest quantization value of output current.
(iii) For a binary input of 1100111 the;
I output current;
II output voltage. (13 marks)

5. (a) State any **two** advantages of LEDs over nixie tubes when used as display devices. (2 marks)

(b) (i) State any **three** components of strip chart recorder.
(ii) With the aid of a labelled diagram, explain the principle of operation of ultra violet chart recorder. (9 marks)

(c) (i) State any **two** advantages of magnetic tape recorder over x-y recorders.
(ii) With the aid of a labelled diagram, explain the operation of a dynamic scattering liquid crystal display (LCD). (9 marks)

SECTION B: INDUSTRIAL MEASUREMENT I

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

6. (a) (i) With the aid of a labelled diagram describe speed measurement using dc tachometer.

(ii) State any **one** advantage and **one** disadvantage of photoelectric - over electrical - tachometers. (8 marks)

(b) An accelerometer output is described by a simple harmonic motion whose amplitude is 0.25 mm and a frequency of 100 Hz.

Determine the:

(i) maximum velocity;
(ii) maximum acceleration. (7 marks)

(c) With the aid of a diagram, explain the principle of measurement of liquid flow velocity using a pitot-tube. (5 marks)

7. (a) (i) With the aid of diagrams, describe the following liquid level measurement:

I float method;
II ultrasonic method.

(ii) State any **two** advantages and **two** disadvantages of utrasonic-over the float - methods of level measurements. (16 marks)

(b) A parallel - plate capacitive transducer is employed in a liquid level measurement in a chemical plant. If the overlapping area of the plates is 1 m^2 and the change in capacitance is found to be 29.5 nF, determine the change in level of liquid.

(Take ϵ_r for liquid = 80 and $\epsilon_o = 8.85 \times 10^{-12}$ F/M) (4 marks)

8. (a) Explain the importance of viscosity measurement in each of the following industries:
(i) food;
(ii) ceramic. (4 marks)

(b) With the aid of a labelled diagram, describe the operation of a falling body viscometer. (6 marks)

(c) (i) Distinguish between specific humidity and relative humidity.
(ii) Explain the principles of operation of each of the following hygrometer:

I Capacitive;
II Piezoelectric

(10 marks)

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