2602/205
TELECOMMUNICATION PRINCIPLES
AND INDUSTRIAL MEASUREMENTS
Oct./Nov. 2023
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING (TELECOMMUNICATION OPTION)

TELECOMMUNICATION PRINCIPLES AND INDUSTRIAL MEASUREMENTS

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
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 any **TWO** questions from section **B** in the answer booklet provided.*
Maximum marks for each part of a question are as indicated.
Candidates should answer the questions in English.

Take: ***Speed of light,*** $c = 3 \times 10^8\ m/s$
Boltzman's constant, $k = 1.38 \times 10^{-23}\ J/K$
Permitivity of free space, $\varepsilon_o = 8.85 \times 10^{-12}\ F/m$
Permability of free space, $\mu o = 4\pi \times 10^{-7}\ H/m$
Acceleration to gravity, $g = 9.81\ m/s^2$

This paper consists of 7 printed pages.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.

Turn over

SECTION A: TELECOMMUNICATION PRINCIPLES

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

1. (a) (i) State **three** roles played by a telecommunication system.

(ii) Explain the function of each of the following parts of a telecommunication system:

(I) modulator;
(II) transmission line.

(7 marks)

(b) (i) Determine the wavelength of the highest frequency in the radio wave spectrum.

(ii) State **three** services that use the frequency band 300 MHz to 3,000 MHz.

(6 marks)

(c) An amplifier has a gain of 60 dB, an input impedance of 75 Ω and feeds a matched load of 140 Ω. The input voltage to the amplifier is 100 μV rms. Determine the load current. (7 marks)

2. (a) (i) Define amplitude modulation.

(ii) Figure 1 shows the waveform of an amplitude modulated signal. The modulation index, m, of the modulated wave is given by $m = Vm/Vc$ where Vm is the modulating voltage and Vc is the carrier voltage. Derive the expression for the instantaneous amplitude of the modulated signal.

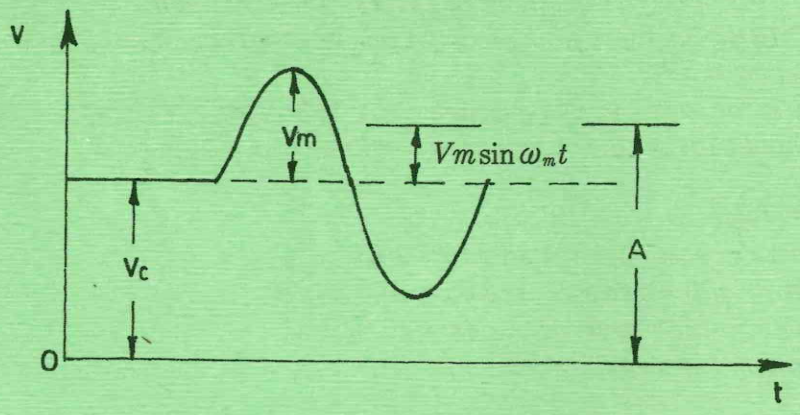

Fig. 1

(iii) Sketch the frequency spectrum of the wave in a (ii).

(10 marks)

(b) Define each of the following with respect to transmission lines:

(i) characteristic impedance;
(ii) standing wave ratio;
(iii) attenuation coefficient.

(3 marks)

(c) Sketch, on the same graph, waveforms showing the amplitude versus distance of voltage and current in a lossless transmission line terminated in a short circuit.

(3 marks)

(d) A transmission line having a characteristic impedance of 70 Ω is terminated by a load of 75 Ω. Determine the:

(i) voltage reflection coefficient;
(ii) voltage standing wave ratio.

(4 marks)

3. (a) (i) State **two** merits of horn antennas.

(ii) With the aid of a diagram, describe the operation of a rhombic antenna and sketch its radiation pattern.

(10 marks)

(b) Sketch a labelled diagram showing the ionospheric layers used in radio wave communication. (4 marks)

(c) An ionospheric layer has a maximum electron density of 4×10^{11} electrons/m^3 and the incident angle of the sky wave entering the layer is 55°. Determine the:

(i) critical frequency;
(ii) maximum usable/frequency;
(iii) optimum working frequency.

(6 marks)

4. (a) State the sources of each of the following types of noise in communication systems:

(i) thermal agitation noise;
(ii) short noise;
(iii) flicker noise.

(3 marks)

(b) An amplifier has an input resistance of 100 kΩ, a bandwidth of 200 kHz and is operated at 20 °C. The input to the amplifier is 100 μV and the output signal-to-noise ratio is 9 dB. Determine the:

(i) input noise voltage;
(ii) input signal-to-noise ratio;
(iii) noise figure, in dB.

(6 marks)

(c) Figure 2 shows a circuit diagrams of a squelch network. Describe its operation.

(5 marks)

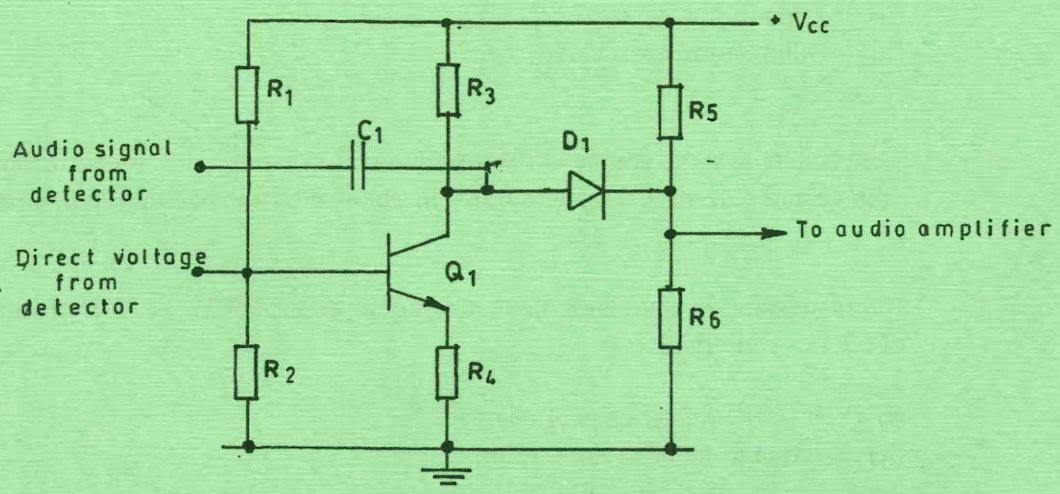

Fig. 2

(d) An AM superheterodyne radio receiver has an intermediate frequency of 455 kHz and is tuned to 1065 kHz. The highest modulating signal frequency at the transmitter is 4.5 kHz. Determine the:

(i) frequency of the local oscillator;
(ii) frequency of the image signal;
(iii) i.f bandwidth.

(6 marks)

5. (a) (i) State **two** merits and **one** demerit of carbon microphones.

(ii) With the aid of a labelled diagram, explain the operation of a ribbon microphone. (8 marks)

(b) Sketch the spectral display of each of the following signals:

(i) sinusoidal carrier amplitude modulated by a rectangular pulse;

(ii) frequency modulated wave.

(6 marks)

(c) (i) Define each of the following optical time domain reflectometer (OTDR) parameters:

(I) dynamic range;
(II) dead zone.

(ii) A 3-digit laboratory digital frequency meter displays a reading of 343 when the gating pulse is set to 15 μS. The true frequency indicated on a standard meter is 22.8 MHz. Determine the:

(I) frequency measured by the laboratory meter;
(II) percentage error in the measurement.

(6 marks)

SECTION B: INDUSTRIAL MEASUREMENTS

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

6. (a) (i) State **three** merits of drag cup tachogenerator.

(ii) With the aid of a labelled diagram, describe angular speed measurement using a dc tachogenerator.

(10 marks)

(b) In the measurement of the angular speed of a machine, 10 pattern points were observed on the disc mounted on the shaft when 5000 flashes per minute were projected on the disc. Determine the speed of the machine. (2 marks)

(c) Figure 3 shows a diagram of U-tube manometer. The float chamber has a diameter of 45 mm and the density of mercury is 13,600 kg/m^3. Application of a pressure, P, of 55 kN/m^2 on the float chamber cause a change of height, h_1 = 5 mm. Determine the:

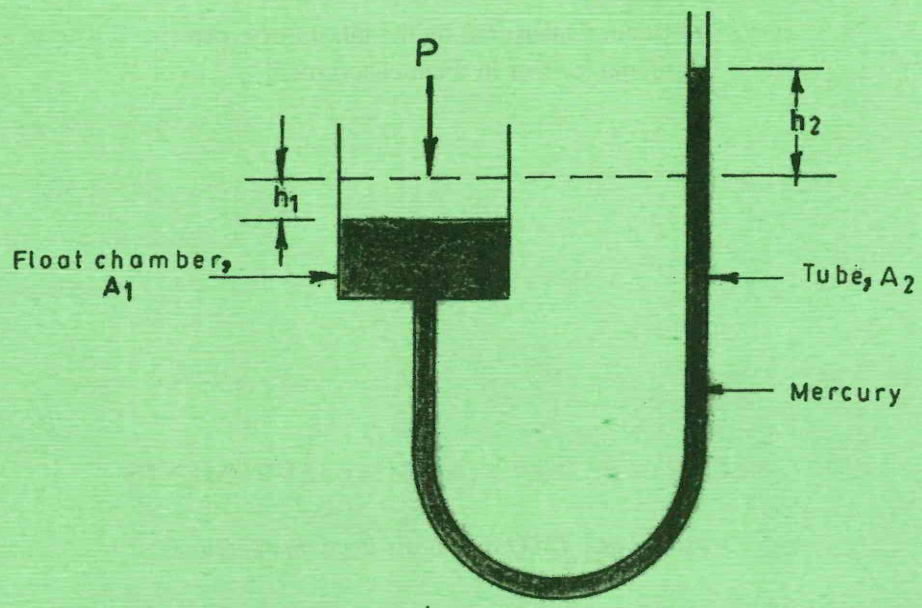

Fig. 3

(i) height, h_2;
(ii) area of float chamber A_1;
(iii) area of tube A_2;
(iv) diameter of tube.

(8 marks)

7. (a) (i) State **three** advantages of radiation methods of liquid-level measurements over float methods.

(ii) With the aid of a labelled diagram, describe liquid-level measurements using gamma-rays.

(9 marks)

(b) (i) Explain the need of using compensating leads in a thermocouple-temperature measurement system.

(ii) Sketch a response curve showing the relationship between the output voltage and the junction temperature of a thermocouple.

(5 marks)

(c) A mercury-in-steel thermometer employs a Bourdon pressure gauge which rotates from 0 radians to 4.7 radians corresponding to a change in temperature from 0° C to 220° C. Determine the:

(i) sensitivity of the instrument in rad/°C;
(ii) temperature for a rotation of 2.1 radians;
(iii) true temperature if the reading in c (ii) is less by 0.12%.

(6 marks)

8. (a) (i) Distinguish between dynamic and kinematic viscosity.

(ii) The tube of a falling sphere viscometer has an internal diameter of 40 mm and is filled with oil of density 810 kg/m^3. A steel ball, having a diameter of 2.5 mm and density of 7600 kg/m^3 was dropped in the oil and travelled between the 180 mm mark and 30 mm mark in 21 seconds. The constant correcting for the tube-wall effects is 0.742. Determine the:

(I) terminal velocity of the steel ball;
(II) kinematic viscosity of oil;
(III) dynamic viscosity of oil

(8 marks)

(b) Explain the principle of operation of each of the following humidity sensors:

(i) capacitive humidity sensor;
(ii) resistive humidity sensor.

(4 marks)

(c) (i) State **three** industrial applications of pneumatic differential pressure transmitter.

(ii) Draw a labelled diagram of an hydraulic load cell and describe its operation.

(8 marks)

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