2602/205
TELECOMMUNICATION PRINCIPLES
AND INDUSTRIAL MEASUREMENTS
June / July 2023
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING (TELECOMMUNICATION OPTION)

MODULE II

TELECOMMUNICATION PRINCIPLES AND INDUSTRIAL MEASUREMENTS

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Non-programmable scientific calculator/ mathematical tables;
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 the questions in English.

Take: ***Speed of light in free space,*** $c = 3 \times 10^8\ m/s$
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 due 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) Define "stored program control" with respect to telephone exchanges.

(ii) Draw a labelled block diagram of a centralized stored program control exchange. (6 marks)

(b) (i) Explain the need of frequency allocation and licensing.

(ii) Table 1 shows various frequency bands and their respective frequency ranges. Complete the table. (6 marks)

Table 1

Frequency band	**Frequency Range**
Medium frequency	_____
_____	3 kHz to 30 kHz
Very high frequency	_____
_____	3 GHz to 30 GHz

(c) Express the following power levels in dBm:

(i) 1 W;
(ii) 1 μW. (4 marks)

(d) Draw a labelled block diagram of a general communication system. (4 marks)

2. (a) Define each of the following with respect to radio wave propagation:

(i) diffraction;
(ii) fading;
(iii) skip distance. (3 marks)

(b) With the aid of a ray diagram, describe multi-hop propagation of low frequency radio waves. (5 marks)

(c) (i) Draw the electrical equivalent circuit diagram of a transmission line.

(ii) Define each of the line parameters in the equivalent circuit diagram in c(i). (6 marks)

(d) A transmission line has an inductance of 5 mH/km and a capacitance of 0.0045 μF/km. If the frequency of operation is 1000 kHz, determine the:

(i) phase delay;
(ii) wavelength of the signal on the line;
(iii) velocity of propagation.

(6 marks)

3. (a) (i) Define each of the following with respect to video cameras:

(I) dynamic range;
(II) resolution;
(III) f-number.

(ii) Explain how a video camera converts the captured optical image into signal current.

(6 marks)

(b) The distance of the object and the image to the convex lens in a video camera are 37.5 mm and 75 mm respectively. The lens has a diameter of 13 mm. Determine the:

(i) focal length of the lens;
(ii) f-number.

(4 marks)

(c) (i) State **three** telecommunication network parameters that can be measured using a network analyzer.

(ii) Figure 1 shows a block diagram of a function generator. Describe its operation.

(8 marks)

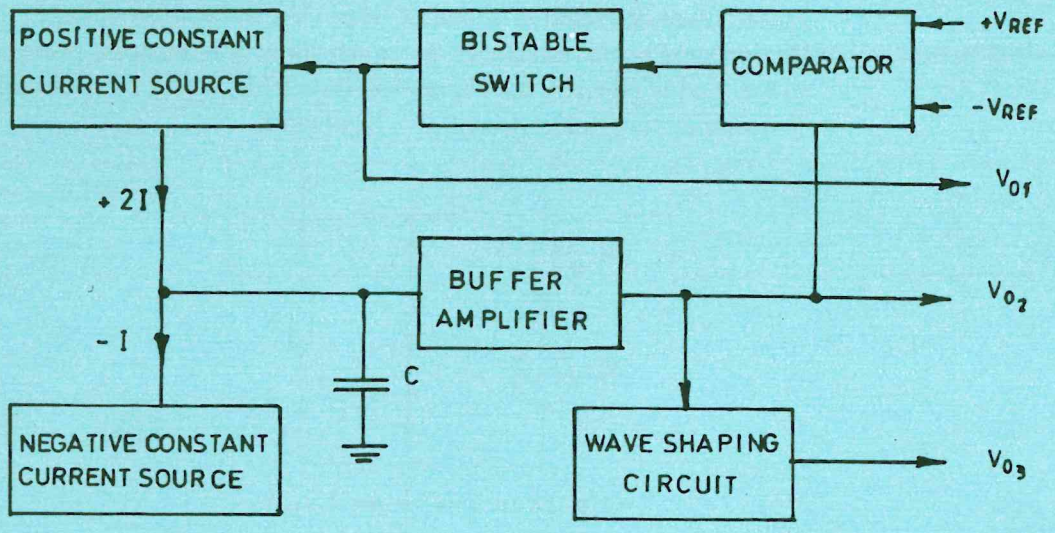

Fig. 1

(d) The data transmitted by an equipment is 1 1 0 0 0 1 0 1 1 and the received data is 0 1 0 1 0 1 0 0 1. Determine the bit error rate. (2 marks)

4. (a) Distinguish between frequency modulation and phase modulation techniques. (2 marks)

(b) A 6 V, 30 MHz sinusoidal carrier is frequency modulated by a 2.5 V, 400 Hz audio sine wave and the resulting deviation is 7.5 kHz. Determine the:

(i) modulation index;
(ii) bandwidth of the modulated signal;
(iii) sensitivity of the modulator;
(iv) power dissipated by the modulated signal in a 12 Ω resistor.

(8 marks)

(c) (i) State the reasons for using antenna coupling networks.

(ii) Draw a labelled diagram of a 3-element Yagi-Uda antenna. (6 marks)

(d) A low frequency transmitting antenna has a radiation resistance of 0.4 Ω and efficiency of 20%. The power input to the antenna is 5000 W. Determine the:

(i) loss resistance;
(ii) current fed to the antenna. (4 marks)

5. (a) (i) State **three** sources of external noise to a telecommunication system.

(ii) Figure 2 shows a circuit diagram of an arrangement to determine the thermal noise power delivered to a load, R where Vn is the noise voltage. Assuming the load and noise resistances are equal, show that the noise power delivered to the load is given by the expression Pn = kTB, where k = Boltzman's constant, T = temperature in Kelvin and B = bandwidth. (7 marks)

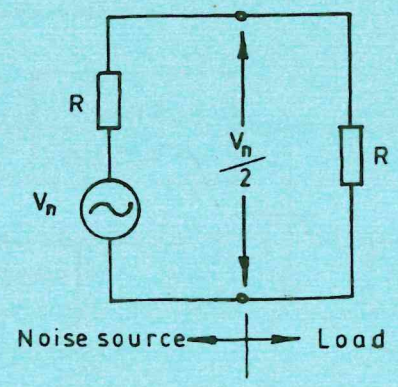

Fig.2

(b) A RF amplifier has a noise voltage of 7.07 μV developed across its input resistance and a noise power of 0.025 pW dissipated in the resistor. The amplifier is operated at a temperature of 21° C. Determine the:

(i) bandwidth of the amplifier;
(ii) input resistance of the amplifier.

(4 marks)

(c) (i) Draw a labelled block diagram of a superheterodyne FM radio receiver.

(ii) The receiver in c(i) has an intermediate frequency of 10.7 MHz and is tuned to a frequency of 97.5 MHz. An input signal of 15 μV produces an output of 50 mW at the tuned frequency. The input voltage at the adjacent channel frequency needed to produce −30 dB output power is 1.8 mV. Determine the:

(I) local oscillator frequency;
(II) adjacent channel ratio.

(9 marks)

SECTION B: INDUSTRIAL MEASUREMENTS

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

6. (a) (i) State **three** environmental factors that can affect the accuracy of a weighing system that uses load cells.

(ii) With the aid of a labelled diagram, describe the operation of a differential pressure transmitter.

(9 marks)

(b) Figure 3 shows a block diagram of a digital humidity meter. State the function of each block. (5 marks)

Fig. 3

(c) Figure 4 shows an arrangement for the measurement of viscosity of a fluid of density 1050 kg/m^3. A quantity of 75 cm^3 was collected in the jar after 480 seconds. For the fluid, determine the:

(i) discharge rate;
(i) terminal velocity;
(iii) dynamic viscosity.

(6 marks)

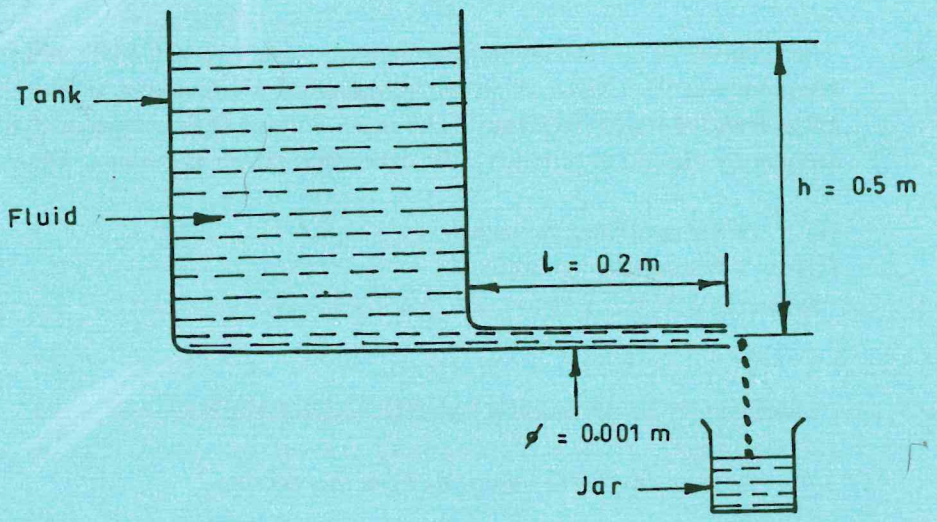

Fig. 4

7. (a) (i) State **three** merits of thermistors when used in temperature measurements.

(ii) With the aid of a labelled diagram, describe temperature measurements using the total radiation pyrometer.

(10 marks)

(b) Draw labelled diagrams showing the following methods of liquid level measurement and state how readings are obtained:

(i) sight glass;
(ii) dip stick.

(6 marks)

(c) Water level in a tank is measured using ultrasonic method. The distance between the bottom of the tank and the transmitter/ receiver unit is 10 m. The ultrasonic wave makes a round trip between transmitter/ receiver unit and the top of the water in 2.5 mS. Taking the velocity of the ultrasonic wave as 1480 m/S, determine the height of the water in the tank. (4 marks)

8. (a) (i) State **two** demerits of potentiometric accelerometers.

(ii) Explain the principle of operation of piezoelectric accelerometers.

(5 marks)

(b) A linear variable differential transformer (LVDT) accelerometer used to measure seismic mass displacement produces an emf of 0.42 mV/mm in the secondary winding for a core displacement of 25 mm. The maximum measurable acceleration is 97 m/s^2; spring constant is 245 N/m and the mass of the core is 0.055 kg. Determine the:

(i) output voltage for maximum core displacement, in mV;
(ii) sensitivity of the accelerometer, in ms^{-2}/mV;
(iii) natural frequency of the accelerometer, in rad/sec.

(6 marks)

(c) Figure 5 shows a diagram of an inclined tube manometer. Assuming that $A_1 >> A_2$, show that the differential pressure, $P_1 - P_2$, is given by the expression $P_1 - P_2 = \rho g h_2$, where ρ = density of the liquid and g = acceleration due to gravity.

(5 marks)

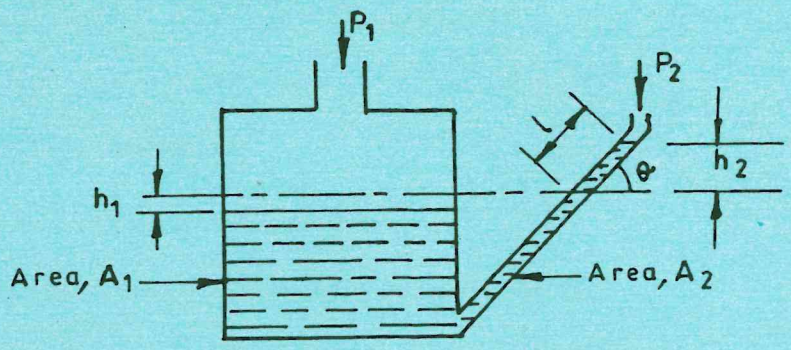

Fig. 5

(d) The maximum acceleration of the piston of a slow - speed oil engine is 2.5 g, where g = acceleration due to gravity. The piston has a mass of 30 grams and diameter of 12 mm. Determine the:

(i) force required to accelerate the piston;
(ii) pressure exerted on the piston by the force in d(i).

(4 marks)

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