2602/205
TELECOMMUNICATION PRINCIPLES AND INDUSTRIAL MEASUREMENTS
June/ July 2022
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.
*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: Velocity of electromagnetic waves in free space $c = 3 \times 10^8 m/s$

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: TELECOMMUNICATION PRINCIPLES

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

1. (a) (i) State **two**:

(i) component parts of a telecommunication system;
(ii) services that use the ultra high frequency band.

(4 marks)

(b) Explain common channel signalling with respect to telephony. (4 marks)

(c) With the aid of a circuit diagram, describe the operation of a transistor mixer used in AM radio receivers. (6 marks)

(d) A superheterodyne radio receiver has a local oscillator of frequency 1520 kHz and is tuned to a frequency of 1065 kHz. The highest modulating signal frequency at the transmitter is 4.5 kHz. Determine the:

(i) intermediate frequency;
(ii) frequency of the image signal;
(iii) minimum i.f. bandwidth.

(6 marks)

2. (a) (i) State **three** causes of interference of radio waves propagated near the earth's surface.

(ii) With the aid of a ray diagram, describe tropospheric scatter propagation of radio waves.

(iii) State **one** demerit of the propagation mode in a(ii).

(10 marks)

(b) A parabolic dish antenna has a mouth diameter of 1.5 m and is used at a frequency of 6.2 GHz. The power fed to the antenna is 3 W. Assuming the antenna efficiency is 65 percent, determine the:

(i) signal wavelength;
(ii) beamwidth between half-power points;
(iii) beamwidth between nulls;
(iv) gain;
(v) effective radiated power.

(10 marks)

3. (a) Explain reasons for using logarithmic units in solving problems in telecommunication systems. (2 marks)

(b) An amplifier with an input impedance of 70 Ω feeds a matched load of 150 Ω. The power gain of the amplifier is 48 dB and the input voltage is 120 μVrms. Determine the:

(i) input power in watts;
(ii) output power in dBm;
(iii) current through the load.

(8 marks)

(c) (i) State **three** losses that occur in a transmission line.

(ii) Describe the construction of balanced twisted-pair cable.

(6 marks)

(d) A transmission line has primary constants, R = 15 Ω/km, L = 3.4 mH/km, G =0 and C = 10 nF/km. Determine the characteristic impedance of the line at an operating frequency of 2 kHz. (4 marks)

4. (a) Define each of the following with respect to Frequency Modulation (FM):

(i) frequency deviation;

(ii) deviation ratio.

(2 marks)

(b) **Figure 1** shows a circuit diagram of asymetrical mode of propagation of radio frequency noise (interference) into mains power supply. With the aid of a circuit diagram, explain how it can be minimized. (6 marks)

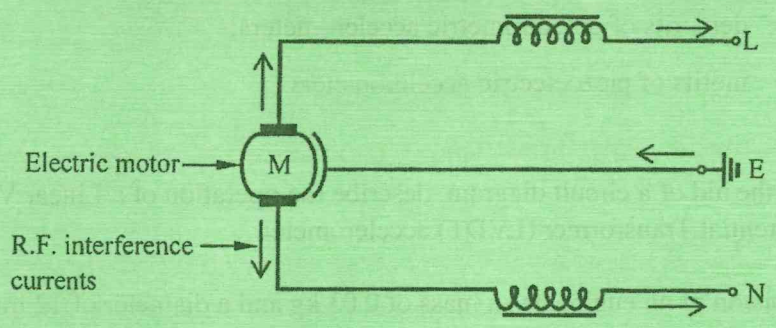

Fig. 1

(c) A 450 W carrier is amplitude modulated to a depth of 60 percent. The modulated signal is passed through an antenna having a resistance of 12 Ω. Determine the:

(i) total radiated power;
(ii) sideband power;
(iii) total current in the antenna;
(iv) percentage saving in power if the carrier is suppressed.

(8 marks)

(d) The binary signal 1011 is multiplied by a sinusoidal signal to produce a minimum shift keying (MSK) wave. The binary signal is in the non-return to zero (NRZ) format. Sketch the waveforms for the:

(i) NRZ signal;
(ii) MSK signal.

(4 marks)

5. (a) (i) State **three** disadvantages of carbon microphones as compared to crystal microphones;

(ii) Draw a labelled diagram of a moving-coil loudspeaker and describe its operation.

(10 marks)

(b) State any **two** types of signals produced by a function generator and sketch their waveforms. (6 marks)

(c) A telecommunication equipment has an input signal voltage of 12 mV and an output noise voltage of 8 μV. The signal-to-noise ratio at the output is 59 dB. Determine the:

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

(4 marks)

SECTION B: INDUSTRIAL MEASUREMENTS

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

6. (a) State **two**

(i) demerits of potentiometric accelerometers;

(ii) merits of piezoelectric accelerometers.

(4 marks)

(b) With the aid of a circuit diagram, describe the operation of a Linear Variable Differential Transformer (LVDT) accelerometer. (6 marks)

(c) The piston of an engine has a mass of 0.03 kg and a diameter of 12 mm. The maximum acceleration of the piston is 2.5 g, where g = acceleration due to gravity. Taking the spring constant as 120 N/mm and g = 9.81 m/s^2, determine the:

(i) force required to accelerate the piston;
(ii) pressure exerted on the piston;
(iii) vertical distance moved by the piston;
(iv) sensitivity of the system.

(8 marks)

(d) State **two** sources of errors in the measurement method in (c). (2 marks)

7. (a) (i) State **four** properties of thermocouples that are useful in industrial applications.

(ii) Sketch the curve of output e.m.f against temperature of a copper-iron thermocouple and explain its shape.

(8 marks)

(b) A thermistor has a resistance of 1285 Ω at a temperature of 304 K. When measuring temperature, its resistance changes to 2135 Ω at the measured temperature. The resistance-temperature relationship is given by the expression:

$$R = R_o \exp\left[\beta\left(\frac{1}{T} - \frac{1}{T_o}\right)\right],$$

where: R = resistance at the measured temperature, T;
R_o = resistance at the reference temperature, T_o;
β = constant for the thermistor material = 3260.

Determine the value of the measured temperature in °C.

(4 marks)

(c) (i) With the aid of a labelled diagram, describe liquid level measurement using hydrostatic pressure method.

(ii) The maximum pressure at the bottom of a tank is 344.2 kN/m^2 at an atmospheric pressure of 250 kN/m^2. Taking the density of the liquid as 1200 kg/m^3 and acceleration due to gravity as 9.81 m/s^2, determine the height of the liquid in the tank.

(8 marks)

8. (a) (i) Define humidity and state how it is expressed.

(ii) With the aid of a labelled diagram, describe the operation of a resistive hygrometer.

(8 marks)

(b) With the aid of a labelled diagram, explain the principle of operation of force-balance pneumatic controllers.

(6 marks)

(c) A single electrical-resistance strain-gauge of resistance 120 Ω and gauge factor of 2.0 is bounded to steel having an elastic-limit stress of 400 MN/m^2 and modulus of elasticity of 200 GN/m^2. If the steel is subjected to a change of stress equal to 0.1 of the elastic range, determine the:

(i) change of stress in steel;
(ii) change of strain in steel;
(iii) change in resistance of the strain gauge.

(6 marks)

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