

2602/205

**TELECOMMUNICATION PRINCIPLES
AND INDUSTRIAL MEASUREMENTS**

Oct./Nov. 2021

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;

Mathematical tables/Non programmable scientific calculator;

Smith chart;

Drawing instruments.

*This paper consists of **EIGHT** questions in **TWO** sections; **A** and **B**.*

*Answer any **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.

*Take: Velocity of electromagnetic waves in free space, $c = 3 \times 10^8 \text{ m/s}$
Boltzmann constant, $K = 1.38 \times 10^{-23} \text{ J/K}$*

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.**

SECTION A: TELECOMMUNICATION PRINCIPLES

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

1. (a) Define each of the following with respect to amplitude modulation:
- (i) lower sideband;
 - (ii) bandwidth.
- (2 marks)
- (b) Show that the total radiated power, P_t , in amplitude wave is given by $P_t = P_c \left(1 + \frac{m}{2}\right)$, where P_c = carrier power
 m = modulation index
- (6 marks)
- (c) A 100 MHz carrier signal is frequency modulated by a 12V, 15 kHz sinusoidal voltage. The instantaneous carrier frequency varies between 99.92 MHz and 100.08 MHz. Determine the:
- (i) peak-to-peak frequency deviation;
 - (ii) modulator sensitivity;
 - (iii) modulation index;
 - (iv) peak phase deviation.
- (8 marks)
- (d) Draw a labelled block diagram of a QPSK modulator. (4 marks)
2. (a) State **three** types of external noise to a communication system. (3 marks)
- (b) A tuned circuit has an inductance of $6.5 \mu H$ and a Q-factor of 70. The circuit resonates at a frequency of 95 MHz and the operating temperature is 275 K. For the circuit, determine the:
- (i) dynamic resistance;
 - (ii) bandwidth;
 - (iii) noise voltage;
 - (iv) noise power.
- (8 marks)
- (c) Draw a labelled block diagram of a superheterodyne frequency modulation (FM) radio receiver and describe its operation. (9 marks)

3. (a) Define each of the following with respect to antenna:
- (i) radiation pattern;
 - (ii) front-to-back ratio;
 - (iii) beam width.
- (3 marks)
- (b) Outline the procedure of measuring the horizontal plane radiation pattern of an antenna.
- (5 marks)
- (c) A load of impedance $Z_L = (24 - j18)\Omega$ is connected to a transmission line with a characteristic impedance $Z_0 = 60\Omega$. Use a Smith Chart to determine the:
- (i) voltage reflection coefficient;
 - (ii) voltage standing wave ratio;
 - (iii) input impedance of a 0.2λ of the line.
- (12 marks)
4. (a) Define each of the following with respect to propagation of radio waves:
- (i) refractive index;
 - (ii) critical frequency;
 - (iii) fading.
- (3 marks)
- (b) With the aid of a ray diagram, describe space wave propagation of radio waves.
- (7 marks)

- (c) Figure 1 shows a block diagram of a telecommunication system. Taking the gain of block 1 = 23 dB, loss in link 1 = -30 dB, input power to block 2 = 316 mW, output power from block 2 = 12.6 W and loss in link 2 = -42 dB. Determine the:

- (i) output power from block 1;
- (ii) input power to block 1;
- (iii) gain of block 2;
- (iv) overall gain or loss, in dB m.

(10 marks)

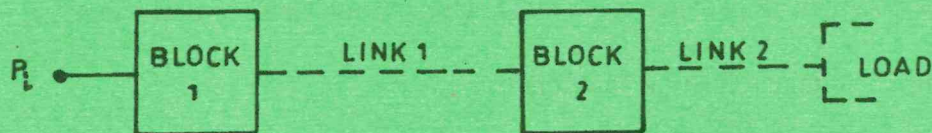


Fig.1

5. (a) State **two**:

- (i) frequency bands used in communication systems;
- (ii) uses of communication systems.

(4 marks)

- (b) Draw a labelled block diagram showing the organization of a centralized stored programme control (SPC) in telephone exchanges. (6 marks)

- (c) With the aid of a labelled diagram, describe the operation of a crystal microphone. (6 marks)

- (d) An r.f pulse signal, with a peak power of 10 kW, has a pulse width of 1 nS and a pulse duration of 1 mS. Determine the:

- (i) percentage duty cycle;
- (ii) average power.

(4 marks)

SECTION B: INDUSTRIAL MEASUREMENTS

Answer any TWO questions from this section.

6. (a) (i) State **three** merits of the toothed rotor variable reluctance tachometer. (11 marks)
- (ii) Describe angular speed measurement using a stroboscope. (3 marks)
- (b) Explain the principle of pressure measurements using a diaphragm. (3 marks)
- (c) A piezoelectric crystal has dimensions of length = 3.0 mm, width = 2.5 mm and thickness = 1.2 mm. The voltage sensitivity of the crystal is 0.07 V-m/N and it develops a voltage of 80 V when a force is applied to it. Determine the:
- (i) effective area of the crystal;
- (ii) pressure on the crystal;
- (iii) force applied. (6 marks)
7. (a) Explain the principle of operation of each of the following thermometers:
- (i) vapour pressure thermometer;
- (ii) constant volume thermometer. (4 marks)
- (b) A thermocouple made of tellurium and bismuth has a sensitivity of $572 \mu\text{V}/^\circ\text{C}$ with sensitivity of tellurium being $500 \mu\text{V}/^\circ\text{C}$. The output of the thermocouple is 85.8 mV when subjected to a temperature difference between reference junction and hot junction. The reference junction temperature is 25°C . Determine the:
- (i) sensitivity of bismuth;
- (ii) temperature difference;
- (iii) temperature of hot junction. (6 marks)
- (c) With the aid of a labelled diagram, describe liquid level measurement using the dielectric liquid level gauge. (7 marks)

- (d) Figure 2 shows a diagram of a float system of measuring liquid level. Taking the density of the liquid as 1200 kg/m^3 , float diameter as 0.3 m and maximum depth (h) of immersion as 1.5 m , determine the maximum mass of the float. (3 marks)

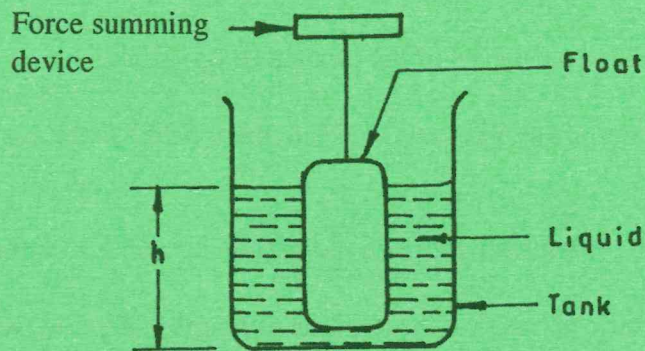
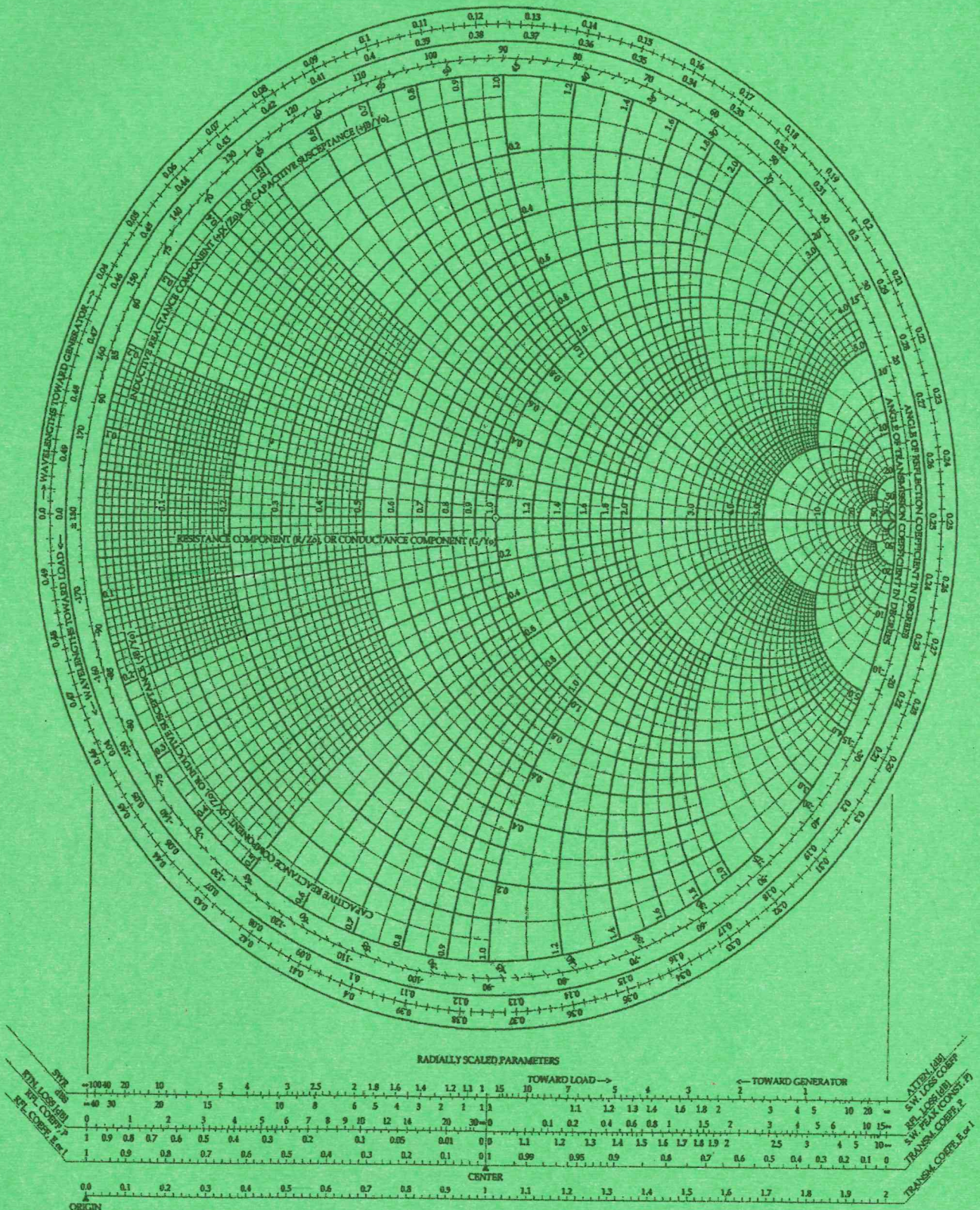


Fig. 2

8. (a) (i) State **two** merits of humistor hygrometers. (6 marks)
- (ii) Explain the measurement of relative humidity using the wet-and-dry bulb method.
- (b) (i) State **two** industrial applications of differential pressure transmitters. (8 marks)
- (ii) Draw a labelled diagram of the transmitter in b (i) and outline its operation.
- (c) A capillary tube viscometer has a capillary tube of diameter 1 mm and length of 30 cm under a head (h) of 20 cm . A quantity of 55 cm^3 of the liquid was collected in a time of 440 seconds . Taking the density of the liquid 1080 kg/m^3 and acceleration due to gravity as 9.81 m/s^2 , determine the:
- (i) flow rate of liquid through the capillary tube;
- (ii) dynamic viscosity;
- (iii) Reynolds number. (6 marks)

Name: Index No.:

Smith Chart



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