2507/206
COMMUNICATION AND
TELECOMMUNICATION SYSTEMS
June/July 2022
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN AERONAUTICAL ENGINEERING (AVIONICS OPTION)

MODULE II

COMMUNICATION AND TELECOMMUNICATION SYSTEMS

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 **FIVE** questions choosing **THREE** questions from section **A** and **TWO** questions from section **B**.*
All questions carry equal marks.
Maximum marks for each part of a question are as shown.
Candidates should answer the questions in English.
Take: ***Free space wave velocity, C*** $= 3 \times 10^8$ m/s
Earth radius, R = 6400 km
Characteristic impedance of free space, Zo $= 120\pi\ \Omega$
Boltzamman's constant, $K = 1.38 \times 10^{-23}\ J/K$

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.

Turn over

SECTION A: COMMUNICATION SYSTEMS

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

1. (a) State **three** applications of varactor diodes in communication systems. (3 marks)

(b) **Figure 1** shows a block diagram of an A.M radio transmitter.

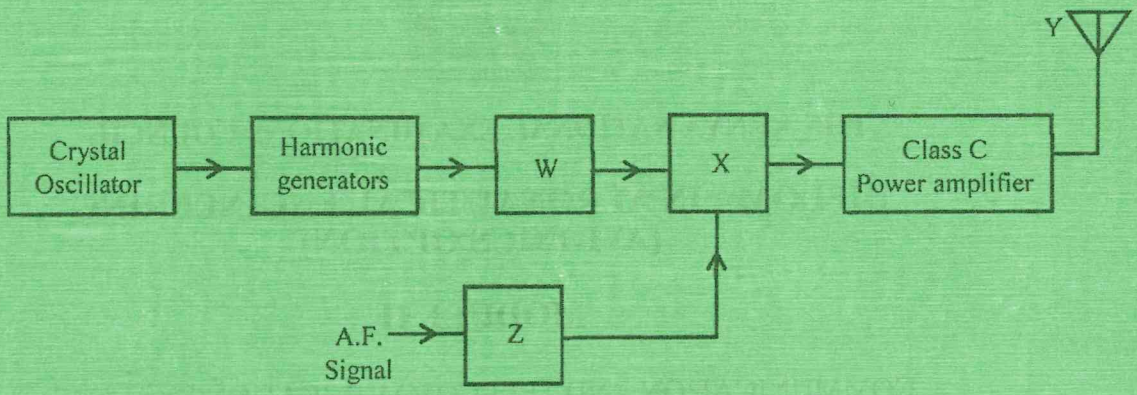

Fig. 1

(i) identify the blocks labelled W, X, Y and Z;
(ii) describe its operation;
(iii) state whether the modulation is high or low level.

(9 marks)

(c) An AM wave is represented by the expression $V = 5(1 + 0.8\cos 6280\,t)\cos 211 \times 10^6 t$ volts. Determine:

(i) modulation index;
(ii) minimum amplitude;
(iii) lower sideband frequency.

(8 marks)

2. (a) State **three** advantages of Single side band over Double side band AM systems.

(3 marks)

(b) **Figure 2** shows a block diagram of a frequency synthesizer. Describe its operation.

(5 marks)

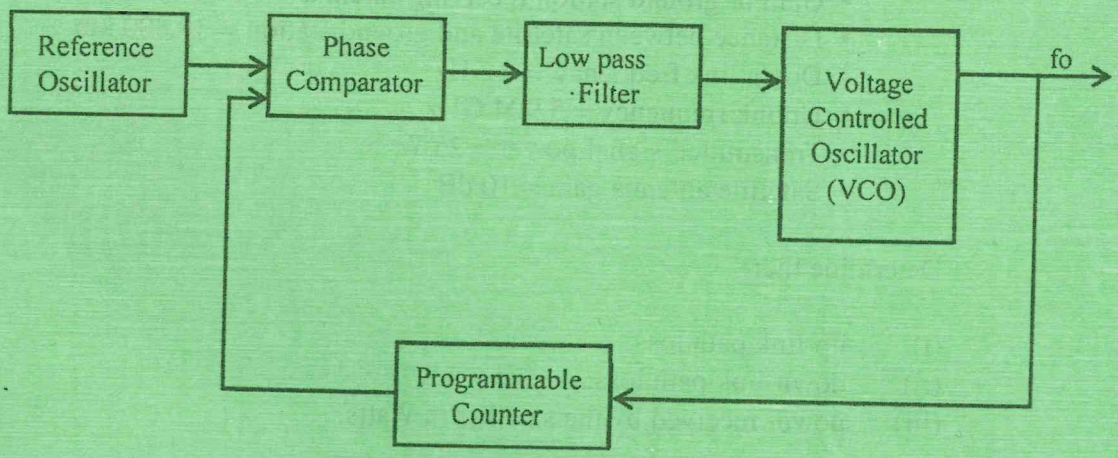

Fig. 2

(c) With the aid of a frequency spectrum, describe the vestigial side band in TV transmission.

(6 marks)

(d) (i) A TV system with an aspect ratio of 4/3 has a total of 525 lines per frame, of which 40 are suppressed. Determine the:

(I) number of active lines;
(II) number of active pixels in a line.

(ii) State **two** common faults that cause a colour TV receiver to display black white image only.

(6 marks)

3. (a) State **three** areas of applications of satellite systems. (3 marks)

(b) Describe each of the following as applied in satellite communications:

(i) frequency division multiple access (FDMA);
(ii) time division multiple access (TDMA).

(4 marks)

(c) The following are the parameters of a satellite communication system:

- Gain of ground station transmitting antenna = 22 dB
- Gain of ground station receiving antenna = 18 dB
- Distance between satellite and ground station = 35,800 km
- Down link frequency = 4 GHz
- Uplink frequency = 5.904 GHz
- Transmitted signal power = 25 W
- Satellite antenna gain = 10 dB

Determine the:

(i) up-link path loss;
(ii) down-link path loss;
(iii) power received by the satellite in Watts.

(9 marks)

(d) State the frequency ranges for each of the following bands:

(i) low frequency (LF);
(ii) super high frequency (SHF).

(4 marks)

4. (a) Define Doppler effect with respect to RADAR systems, stating the expression for its frequency. (2 marks)

(b) Figure 3 shows a block diagram of a distance measuring instrument (DME) used in aircraft navigation. Explain its operation. (5 marks)

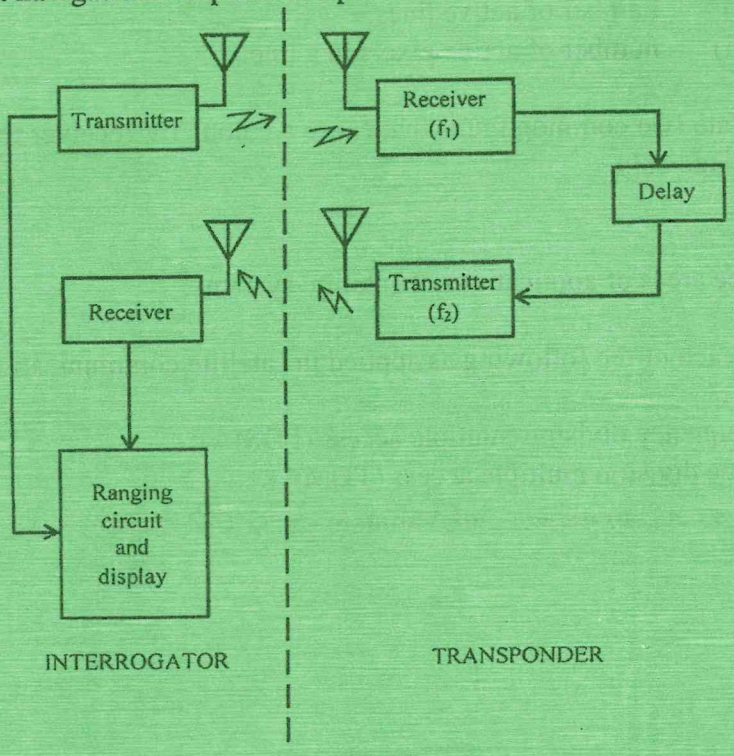

Fig. 3

(c) With the aid of a labelled block diagram, describe the operation of a Moving Target Indicator (MTI) RADAR system. (8 marks)

(d) An 850 MHz RADAR system operating over a range of 20 km produces a minimum receivable power of 300 pW. The antenna capture area is $6\,m^2$ and the target cross-section area is $18\,m^2$. Determine the peak pulsed power radiated. (5 marks)

5. (a) List **three** challenges faced in the implementation of HDTV system. (3 marks)

(b) **Figure 4** shows a simplified block diagram of a digital TV communication system.

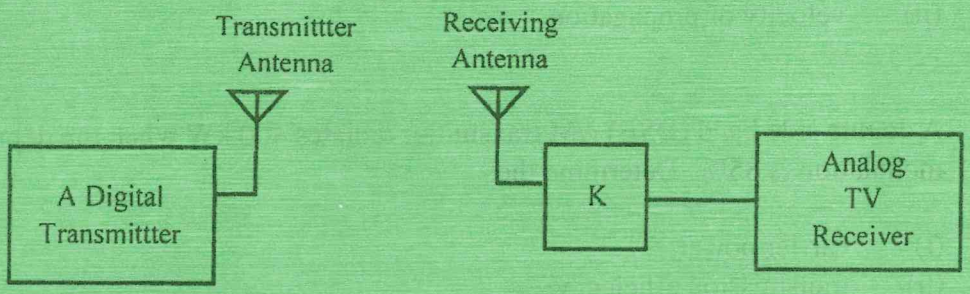

Fig. 4

(i) identify the block labelled K;
(ii) describe the operation of the system.

(5 marks)

(c) With the aid of a labelled block diagram, describe the operation of a closed circuit TV system. (7 marks)

(d) (i) Distinguish between pico-cells and macro-cells as used in GSM technology.
(ii) Describe Mobile Switching Centre (MSC) as used in GSM systems.

(5 marks)

SECTION B: TELECOMMUNICATION PRINCIPLES

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

6. (a) (i) Distinguish between travelling wave and standing wave antennas.
(ii) State **two** merits of travelling wave antennas. (4 marks)

(b) With the aid of a labelled diagram, describe the offset feed method of microwave antennas. (8 marks)

(c) A 30 m high monopole antenna is supplied with 100 A at 300 kHz. Determine the:

(i) effective length of the antenna;
(ii) radiated power;
(iii) electric field strength at a point 120 km away.

(8 marks)

7. (a) Distinguish between phase and group velocities with respect to transmission lines.

(2 marks)

(b) With the aid of a ray diagram, describe space wave propagation of radio waves.

(6 marks)

(c) A transmission line operating at 200 MHz has the following primary constants:

$R = 0.01\,\Omega/km$; $L = 1\,mH/km$, $G = 1\,\mu Mho/km$ and $C = 1\,\mu F/km$. Determine the:

(i) characteristic impedance;
(ii) velocity of propagation.

(6 marks)

(d) A double side band (DSB) AM transmitter radiates 400 kW when the depth of modulation is 85%. Determine the:

(i) carrier power;
(ii) transmission efficiency;
(iii) power of the side bands.

(6 marks)

8. (a) (i) Define each of the following with respect to waveguides:

(I) cut-off frequency;
(II) propagation mode.

(ii) State **two** methods of energy coupling used in waveguides.

(4 marks)

(b) With the aid of a labelled diagram, explain the principle of operation of a parametric amplifier.

(7 marks)

(c) **Figure 5** shows a diagram of a rectangular waveguide. It propagates at $TE_{1,0}$ mode at a frequency of 10 GHz.

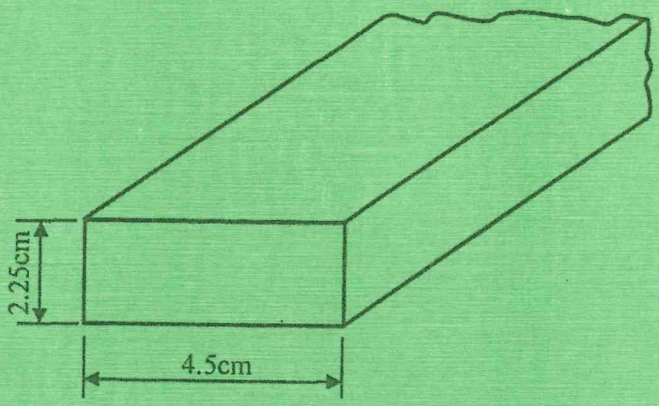

Fig. 5

Determine the:

(i) cut-off wavelength;
(ii) guide velocity;
(iii) characteristic impedance.

(9 marks)

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