

2507/206

COMMUNICATION AND TELECOMMUNICATION SYSTEMS

Oct./Nov. 2023

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 by choosing 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: Free space wave velocity, $c = 3 \times 10^8$ m/s

Characteristic impedance of free space, $Z_0 = 120\pi \Omega$

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: COMMUNICATION SYSTEMS

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

1. (a) Define each of the following with respect to satellite communication:

- (i) Apogee distance;
- (ii) Non-synchronous orbit.

(2 marks)

(b) (i) Figure 1 shows a labelled diagram of an earth satellite station. Describe its operation.

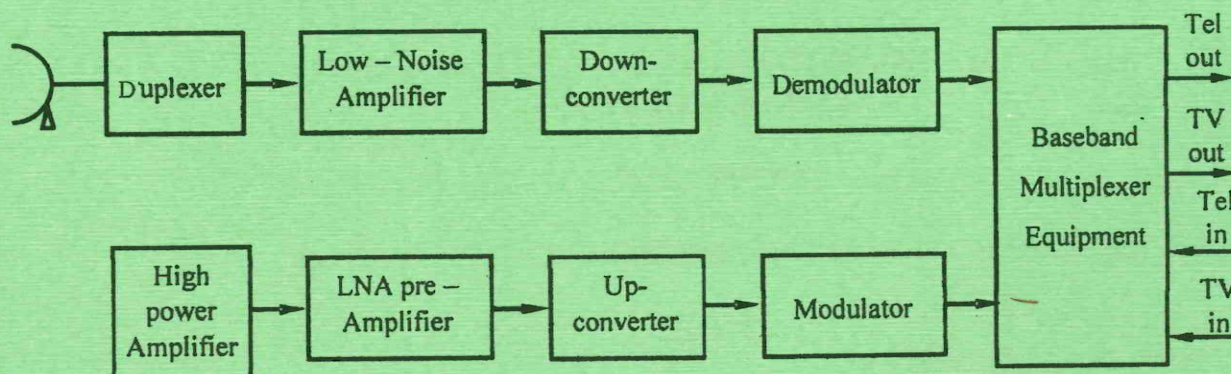


Fig. 1

(ii) With the aid of a labelled diagram, describe the operation of 5-node star VSAT network. (9 marks)

(c) (i) A satellite located 20,000 km above the earth surface radiates 1.5 W using an antenna whose gain is 18dB. Determine the:

- (I) power flux density at the earth's surface.
- (II) power received by an antenna whose effective aperture area is 12 m².

(ii) An earth satellite station, operating at 6 GHz, transmits 3 kW power using an antenna whose gain is 44 dB. The signal is received 50,000 km away by an antenna whose gain is 15 dB. Determine the receiver power in dB. (9 marks)

2. (a) Define each of the following with respect to radar systems:

- (i) Angle resolution;
- (ii) Maximum unambiguous range.

(2 marks)

- (b) With the aid of a labelled block diagram, describe the operation of a pulsed radar system. (8 marks)
- (c) An 8 GHz Doppler radar system scans a target over a range of 800 km in 25 seconds. Determine the doppler frequency shift. (3 marks)
- (d) A radar system, operating at 800 MHz over a range of 25 km, radiates 15 kW using an antenna whose capture area is 5 m^2 . The target cross-sectional area is 12 m^2 . Determine the:
- minimum receivable power;
 - range over which the received power would be doubled.
- (7 marks)
3. (a) (i) List **three** challenges facing migration to digital TV transmission.
- (ii) With the aid of a block diagram, describe monochrome TV transmitter. (10 marks)
- (b) Four TV channels are each allocated a bandwidth of 6 MHz and a guardband of 200 kHz between channels. The allocation starts from 600 MHz.
- determine the range of each channel;
 - draw the transmission spectrum.
- (6 marks)
- (c) A PAL TV standard consists of 625 lines per frame and 25 frames per second. Determine the:
- line frequency;
 - field scan period.
- (4 marks)
4. (a) (i) Define Amplitude Modulation (A.M).
- (ii) With the aid of a circuit diagram, describe the operation of a cowan modulator. (7 marks)

- (b) Figure 2 shows a block diagram of the phase shift method of generating single side band (SSB) signal. Obtain the expression for the output voltage, V_o .

(7 marks)

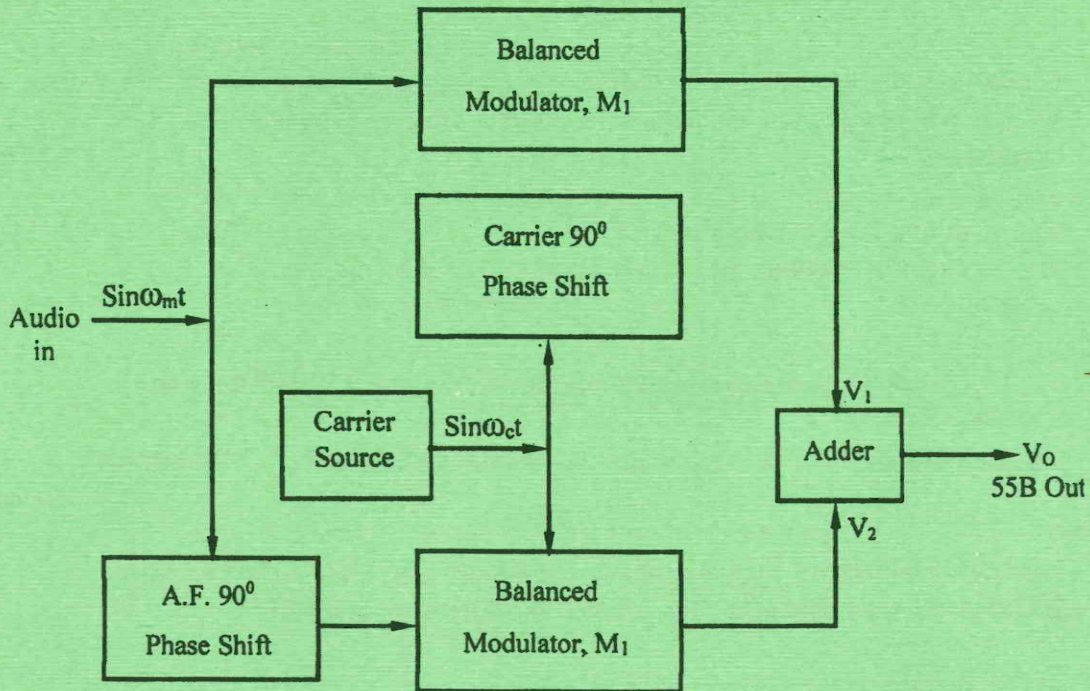


Fig. 2

- (c) An AM signal has a 10 V peak, 40 MHz carrier which is modulated by a 10 kHz tone to a depth of 50%. Determine the:

- (i) peak modulating signal voltage;
- (ii) bandwidth;
- (iii) power delivered to a 50 Ω load.

(6 marks)

5. (a) List any two:

- (i) types of colour TV systems;
- (ii) features of HDTV system.

(4 marks)

- (b) A closed circuit TV system consists of four TV cameras with IP addresses network video recorder (NVR) router and other peripherals. Draw a labelled block diagram of the system and describe its operation.

(6 marks)

(c) (i) Describe each of the following Digital TV transmission as applied to emerging technologies.

- (I) streaming stored video and audio;
- (II) real time interactive video and audio.

(ii) **Figure 3** shows a simplified block diagram of a digital TV communication system. Describe its operation. (10 marks)

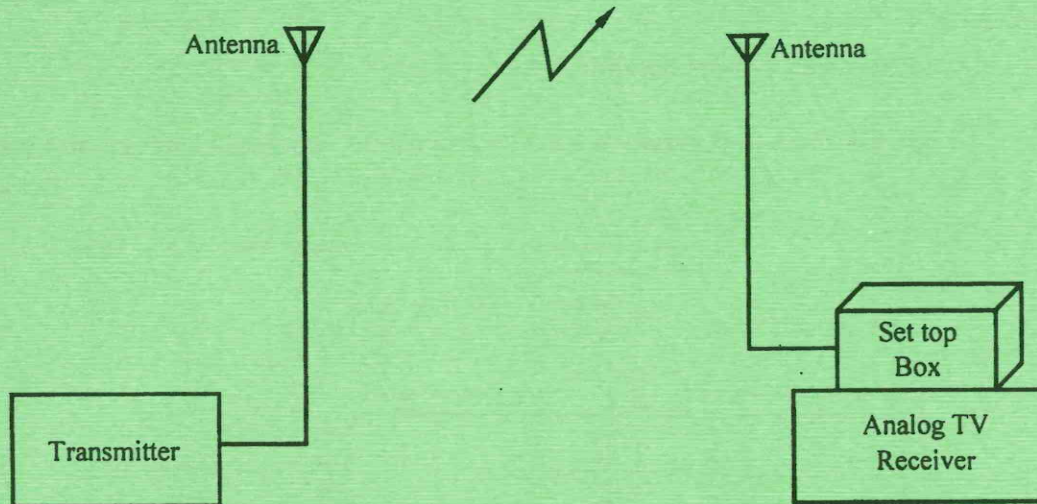


Fig. 3

SECTION B: TELECOMMUNICATION PRINCIPLES

Answer *TWO* questions from this section.

6. (a) (i) State two losses that occur in transmission lines.
- (ii) Draw the equivalent electrical circuit diagram for each of the following transmission lines:

(I) short circuited $\frac{\lambda}{4}$ lines;

(II) open circuited $\frac{\lambda}{4}$ lines.

(6 marks)

- (b) With the aid of a labelled diagram, describe double-stub matching as used in transmission lines.

(6 marks)

- (c) A radiating antenna, 2 m long, has a radiation antenna of 75Ω and a power gain of 30 dB. When driven by a current of 2 A, its signals are received 80 km away. Determine the:

- (i) radiated power;
- (ii) electric field strength at the receiving point;
- (iii) received power;
- (iv) transmission path loss.

(8 marks)

7. (a) (i) State two areas of application of waveguides.
- (ii) Figure 4 shows a diagram of a cavity resonator. Describe its tuning process.

(5 marks)

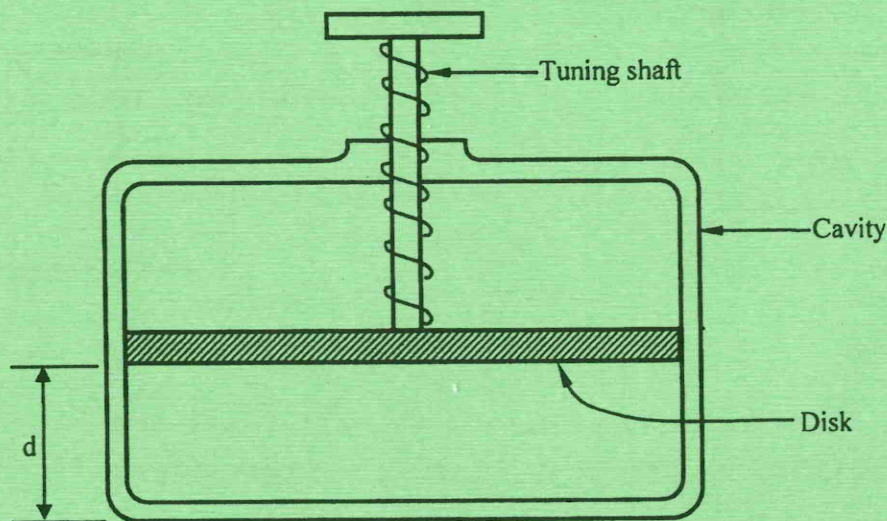


Fig. 4

- (b) A parametric amplifier has a sinusoidal input voltage signal and a pulsed pump voltage:

- (i) Draw the input and output waveforms;
- (ii) Describe the operation of the amplifier.

(7 marks)

- (c) A rectangular waveguide measuring 4 cm x 8 cm has a signal of 12 GHz propagating in it. For the $TM_{2,2}$ mode, determine the:

- (i) cut-off wavelength;
- (ii) free-space wavelength;
- (iii) phase velocity.

(8 marks)

8. (a) (i) Define the following terms with respect to noise:

(I) signal to noise ratio;

(II) noise figure.

(ii) State the two main sources of noise.

(4 marks)

(b) The first stage of a two-stage R.F amplifier has an output resistance of $20\text{ k}\Omega$ and a voltage gain of 10. The input resistance and the noise resistance is $500\ \Omega$ and $2\text{ k}\Omega$ respectively. The second stage has an output resistance of $400\text{ k}\Omega$, a voltage gain of 20, an input resistance of $80\text{ k}\Omega$ and a noise resistance of $10\text{ k}\Omega$.

(i) Draw a schematic circuit diagram of the arrangement;

(ii) Determine the:

(I) equivalent noise resistance of the two stage amplifier;

(II) noise figure.

(12 marks)

(c) An FM transmitter uses a carrier frequency of 105 MHz. It is modulated to a frequency of 105.07 MHz by a message signal. Determine the:

(i) frequency deviation;

(ii) carrier swing.

(4 marks)

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