2507/206
COMMUNICATION AND
TELECOMMUNICATION SYSTEMS
June/July 2019
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;
Non-programmable scientific calculator.
*This paper consists of **EIGHT** questions in **TWO** sections; **A** and **B**.*
*Answer **FIVE** questions by choosing 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 light*** $c = 3 \times 10^8$ m/s
Earth radius R = 6400 km

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

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

(I) angle of inclination;
(II) apogee.

(2 marks)

(b) (i) Explain frequency division multiple access (FDMA) with respect to satellite communication.

(ii) Describe the no-break power supply connection used in an earth satellite station. (6 marks)

(c) (i) An earth satellite station operates at 6 GHz using a parabolic dish antenna whose mouth diameter is 36 m with an illumination efficiency of 80%. The link noise temperature is 88 K. Determine the G/T ratio of the station in dB/K.

(ii) A satellite in a synchronous orbit operates at 4000 MHz using transmitting and receiving antennas whose gains are 15 dB and 40 dB respectively. Determine the:

(I) free space path loss;
(II) total loss;
(III) power received when the radiated power is 500 W.

(12 marks)

2. (a) (i) List **two** advantages of frequency modulation (FM) over amplitude modulation (AM).

(ii) An AM system has a carrier wave, $E_c \sin \omega_c t$ and the modulating signal is $E_m \sin \omega_m t$. Derive the expression for the instanteneous value, e_{AM}, of the modulated signal when the modulation index is m. (11 marks)

(b) An FM system has a modulating signal of 15 kHz and the modulation index is 6. Determine the:

(i) frequency deviation;
(ii) system bandwidth.

(4 marks)

(c) An AM transmitter drives a current of 18 A into an antenna when the depth of modulation is 52%. Determine the depth of modulation if simultaneous modulation by another sinewave increases the transmitter current to 21 A. (5 marks)

3. (a) State the function of each of the following in TV systems:

(i) duplexer;

(ii) TV camera.

(2 marks)

(b) Figure 1 shows a simplified block diagram of the colour picture signal chain of a colour TV receiver. Describe its operation. (5 marks)

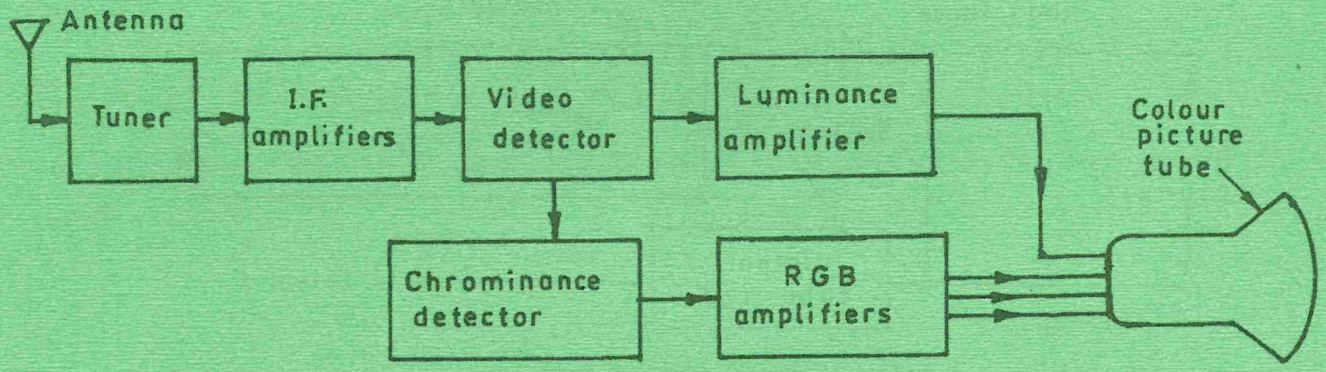

Fig. 1

(c) (i) With the aid of a response curve, describe interleaving as applied to transmission of colour TV picture signal.

(ii) With the aid of a labelled construction diagram, describe the operation of a charge coupled device (CCD) sensor used in TV cameras.

(13 marks)

4. (a) Describe each of the following emerging technologies:

(i) digital TV transmission;

(ii) streaming stored audio/video.

(6 marks)

(b) Draw a labelled block diagram of an FM stereo encoder and describe its operation. (9 marks)

(c) A transistor reactance modulator has an oscillator whose capacitance and inductance are 20 pF and 8 nH respectively. When the modulating signal is applied, the effective capacitance increases by 4 pF. Determine the frequency deviation of the FM wave.

(5 marks)

5. (a) Define each of the following as applied to radar systems:

(i) duty cycle;

(ii) 2nd return echoes.

(2 marks)

(b) (i) Figure 2 shows a line pulser unit of a pulsed radar. Describe its operation.

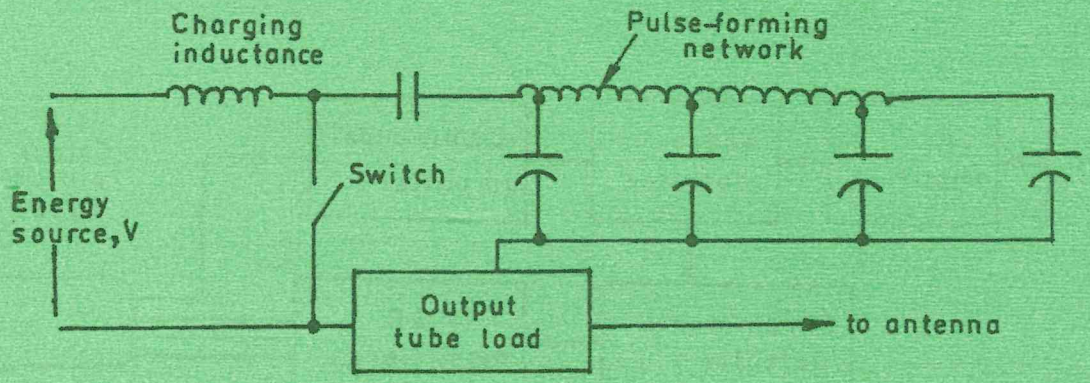

Fig. 2

(ii) With the aid of a labelled block diagram, describe the operation of a continuous wave Doppler radar system. (9 marks)

(c) (i) An 8 GHz radar system scans a target over a range of 600 km in 20 seconds. Determine the:

(I) target relative velocity;
(II) doppler frequency shift.

(ii) A radar system, operating at 920 MHz over a range of 62 km, uses an antenna whose capture area is 9 m^2 to radiate 10 kW towards a target whose cross-sectional area is 10 m^2. Determine the minimum receivable power.

(9 marks)

SECTION B: TELECOMMUNICATION PRINCIPLES

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

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

(i) fading;
(ii) critical frequency.

(2 marks)

(b) (i) Table 1 shows data for the received signal, E_R, with changes in distance for a UHF link.

(I) Plot the response curve;

(II) Explain its shape;

(III) Determine the signal received at a distance of 17.5 km.

Table 1

Distance (km)	0	4.5	6.5	10.5	11.5	15	16.5	19.5	23	25.5	32.5
Received signal (dB)	40	68	43.5	57	34	43	29	35	18	23	8

(ii) A UHF radio link uses a transmitting and receiving antennas of 120 m and 90 m heights respectively. Determine the maximum range of the link. (8 marks)

(c) A communication system has an input signal of 40 μV and an output signal of 8 mV . The noise at the input is 10 nV while the noise at the output is 0.5 μV . Determine the system:

(i) input signal-to-noise ratio;

(ii) output signal-to-noise ratio;

(iii) noise figure, in dB.

(7 marks)

(d) List any **three** reasons for using logarithmic units in communication systems.

(3 marks)

7. (a) (i) List any **two** advantages of optical fibres over coaxial cables in signal transmission.

(ii) With the aid of a labelled block diagram, describe the operation of a communication system using optical fibre medium.

(10 marks)

(b) With the aid of a raypath diagram, describe signal propagation in a graded index optical fiber. (4 marks)

(c) An optical fiber has a core of refractive index of 1.76 and cladding of refractive index of 1.71. Determine the:

(i) numerical aperture;

(ii) maximum angle of incidence;

(iii) critical angle.

(6 marks)

8. (a) (i) List any **two** areas of application of a klystron oscillator.

(ii) Figure 3 shows a schematic block diagram of a microwave transmit/receive switch using a PIN diode. Describe its operation. (6 marks)

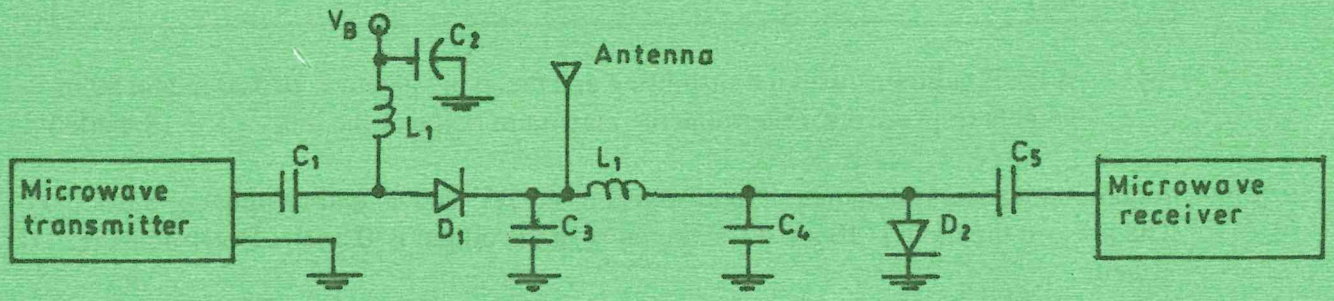

Fig. 3

(b) Figure 4 shows the input signal voltage waveform, Vin, and the pump signal waveform, Vpump, fed into a parametric amplifier. With the aid of the output voltage waveform, describe the operation of the amplifier. (6 marks)

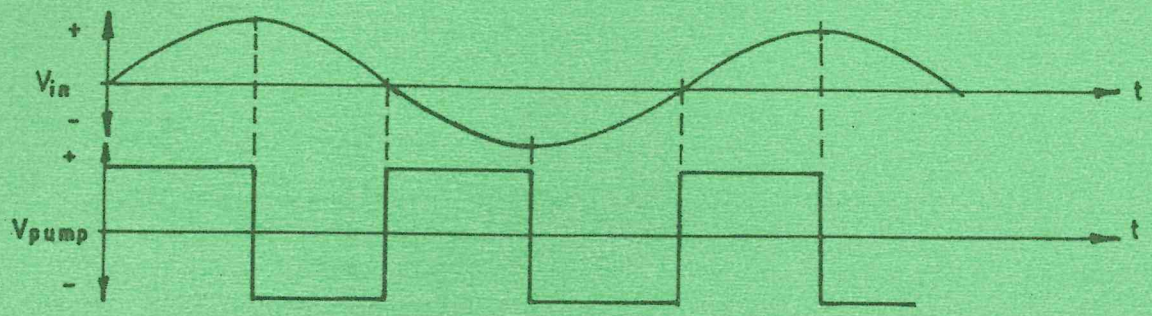

Fig. 4

(c) (i) A lossless transmission line has an inductance of 440 $\mu H/m$ and a capacitance of 0.085 $\mu F/m$. Determine the:

(I) characteristic impedance;

(II) phase velocity.

(ii) A rectangular wave guide measuring 5 cm x 3 cm has a signal of 6 GHz propagating in it. For the dominant mode, $TE_{1,0}$ mode, determine the:

(I) cut-off wavelength;

(II) cut-off frequency.

(8 marks)

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