2207/303
COMMUNICATION AND NAVIGATION
SYSTEMS
Oct./Nov. 2017
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN AERONAUTICAL ENGINEERING AVIONICS (COMMUNICATION AND NAVIGATION OPTION)

COMMUNICATION AND NAVIGATION SYSTEMS

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Mathematical tables/non-programmable scientific calculator.
*Answer **FIVE** of the **EIGHT** questions in the answer booklet provided.*
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.

This paper consists of 6 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

1. (a) Define each of the following with respect to pulse modulation systems:

(i) quantization noise;

(ii) Nyquist sampling rate. (2 marks)

(b) (i) A data transmission link consists of two four-input concentrators and a multiplexer. With the aid of a labelled block diagram, describe the operation of the link.

(ii) With the aid of a labelled diagram, describe the operation of a star network topology. (10 marks)

(c) An a.f. signal of $4 \sin 600\pi t$ volts is transmitted using 8-bit Pulse Code Modulation (PCM). Determine the:

(i) Nyquist sampling rate;

(ii) quantization error voltage;

(iii) signal-to-quantization noise ratio. (8 marks)

2. (a) (i) List **two** losses that occur in optical fibres.

(ii) With the aid of a labelled diagram, describe the operation of a light emitting diode. (8 marks)

(b) An optical fibre has a core of refractive index of 1.72 and cladding whose refractive index is 1.48. If the signal wavelength is $0.66\ \mu m$ and the core diameter is $4\ \mu m$, determine the:

(i) numerical aperture;

(ii) signal frequency;

(iii) number of modes that can be propagated. (6 marks)

(c) Table 1 shows data for an optical fibre.

(i) Plot the response curve.

(ii) Determine the:

(I) frequency of operation;
(II) spectrum of the fibre in wavelengths. (6 marks)

Table 1

Wavelength (nm)	100	200	300	400	500	600	400	800	900
Output signal (μV)	-	9.5	22	38	45	36.5	18.5	11	5

3. (a) (i) List **two** errors associated with the very high frequency ormirange (VOR) radio navigation aid.

(ii) Sketch the A scope radar display and explain its shape. (10 marks)

(b) Explain how marker beacons are used as navigation aids in instrument landing systems. (5 marks)

(c) A radar system, operating at 8 GHz over a bandwidth of 750 kHz, uses an amplifier with a noise figure of 9 dB and an antenna whose diameter is 2 m. If the antenna radiates 20 kW and the target cross-sectional area is 6 m^2, determine the radar range. (5 marks)

4. (a) (i) List **three** areas of application of a varactor diode.

(ii) Draw a labelled block diagram of a high-level amplitude modulation (AM) transmitter and describe its operation. (9 marks)

(b) An FM stereo encoder has a carrier wave of 19 kHz and a stereo signal sub-carrier of 38 kHz. If the a.f input signal ranges from O Hz to 15 kHz, draw a labelled spectral band for the composite signal. (3 marks)

(c) An AM system has a 20 kW carrier wave of amplitude 10 V and a modulating signal of amplitude 8 V.

(i) Sketch the AM waveform;

(ii) Determine the:

(I) modulation index;
(II) radiated power;
(III) transmission efficiency. (8 marks)

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

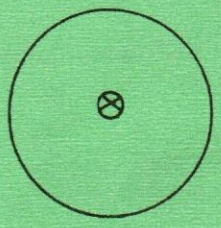
(i) effective aperture;

(ii) front-to-back ratio. (2 marks)

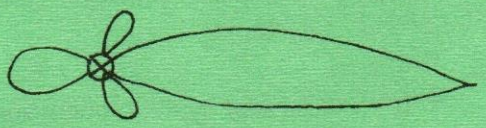
(b) (i) With the aid of a labelled diagram, describe the operation of a horn-feed microwave antenna.

(ii) Figure 1 shows the polar diagrams of two different antennas. Explain, with reason(s), which antenna is suitable for:

(I) radiation of signals at 700 kHz;
(II) reception of TV signals. (9 marks)



Antenna A



Antenna B

Fig. 1

(c) A 5-element dipole end-fire array radiates 5 kW at 60 MHz towards a receiving antenna located 120 km away. If the path attenuation is 25 dB, determine the:

(i) power flux density at the receiving point;

(ii) power received by the antenna if its gain is 12 dB. (9 marks)

6. (a) (i) List **two** factors that determine the fidelity of a radio receiver.

(ii) With the aid of a labelled block diagram, describe the operation of an AM superheterodyne radio receiver. (10 marks)

(b) Table 2 shows data for a radio receiver tuned between 80 MHz and 120 MHz.

(i) plot the sensitivity response curve;

(ii) determine the:

(I) receiver sensitivity;
II) frequencies at which sensitivity is 27.5 μV. (6 marks)

Table 2

Input signal (μV)	44	31.5	22.5	15	10	10.5	17	25	38.5
Frequency (MHz)	80	85	90	95	100	105	110	115	120

(c) With the aid of a circuit diagram, describe the operation of a series i.f trap in a radio receiver. (4 marks)

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

(i) perigee;

(ii) angle of inclination. (2 marks)

(b) (i) Explain "program tracking" as applied to an earth station antenna.

(ii) With the aid of a labelled diagram, describe the operation of a tunnel diode amplifier. (10 marks)

(c) A rectangular waveguide, having a plane separation of 4 cm, operates at 12 GHz when carrying the dominant mode. Determine the:

(i) cut-off wavelength;

(ii) guide wavelength;

(iii) group velocity;

(iv) phase velocity. (8 marks)

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

(I) 2nd return echoes;
(II) maximum unambiguous range;

(ii) With the aid of a labelled diagram, describe the plan-position indicator (PPI) radar display. (9 marks)

(b) Figure 2 shows a line-pulser used in pulsed radar systems. Explain its operation. (4 marks)

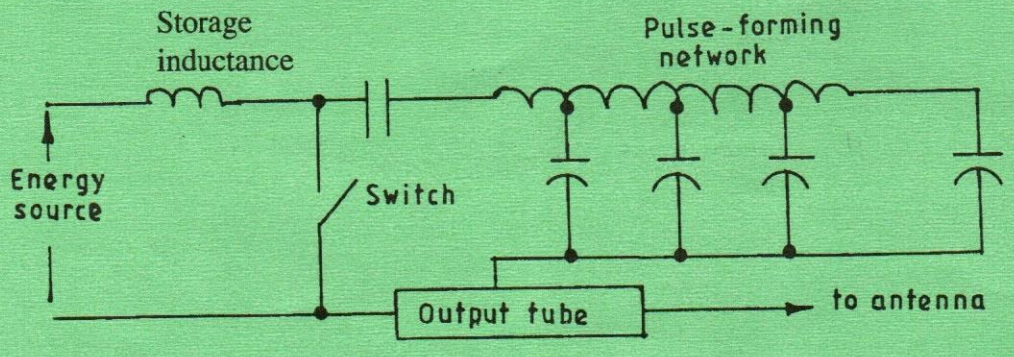


Fig. 2

(c) An MTI radar system operates at 4 GHz with a pulse repetition frequency of 900 pulses per second. Determine the lowest three blind speeds for the radar. (7 marks)

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