2207/303
COMMUNICATION AND
NAVIGATION SYSTEMS
Oct./Nov. 2016
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:
Mathematical tables/non-programmable scientific calculators;
Answer booklet.
*Answer any **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
Impedance of free space, £= 377 Ω

This paper consists of 5 printed pages.

Candidates should check the question paper to ascertain that all pages are printed as indicated and that no questions are missing.

Turn over

1. (a) List any **two**:

(i) errors associated with the very high frequency Omnirange (VOR) transceivers;
(ii) applications of the automatic direction finder. (4 marks)

(b) (i) With the aid of a labelled diagram, describe the operation of an Instruments Landing System (ILS).

(ii) A Doppler radar system, operating at 8GHz, scans a target over a range of 600 km in 20 secs. Determine the:
I. doppler frequency shift;
II. target relative velocity. (13 marks)

(c) A tracking radar system, operating at 800 MHz, produces a minimum receivable power of 100 pW over an unknown range. The antenna capture area is 4 m^2, the target cross-sectional area is 12 m^2, and the radiated power is 20 kW. Determine the radar range. (3 marks)

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

(ii) An AM wave varies between a maximum value of E_{max} and a minimum value of E_{min}.

I. Sketch the wave form;
II. Derive the modulation index in terms of E_{max} and E_{min}. (9 marks)

(b) A double sideband AM transmitter drives a current of 18 A into an antenna when the depth of modulation is 60%. Simultaneous modulation by another sinewave increases the transmitter current to 21 A. Determine the:

(i) new depth of modulation;
(ii) transmission efficiency;
(iii) total radiated power. (11 marks)

3. (a) Define each of the following as applied to radio receivers:

(i) sensitivity;
(ii) noise figure. (2 marks)

(b) (i) Figure 1 shows a section of a radio receiver circuit. Describe its operation.

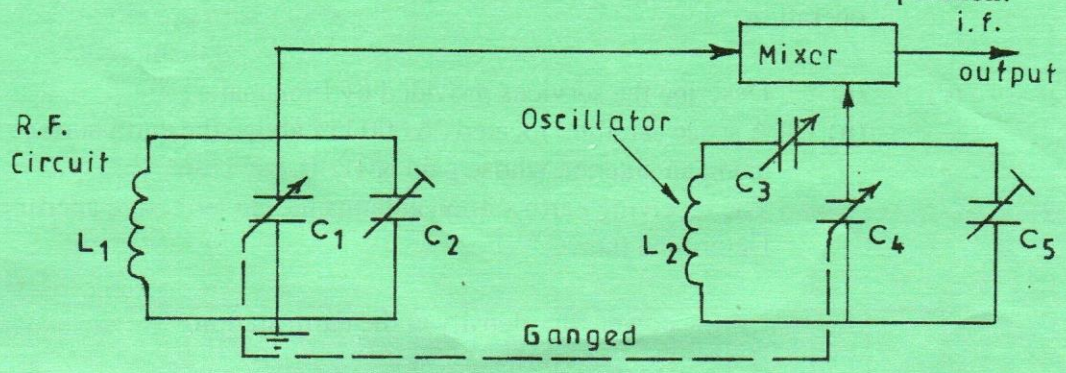

Fig. 1

(ii) Draw a labelled bock diagram of a frequency modulation stereo receiver and describe its operation. (12 marks)

(c) An AM radio receiver tuned to 900 kHz, has an i.f. of 465 kHz. Determine the:

(i) image signal frequency;
(ii) local oscillator frequency;
(iii) i.f. bandwidth if the tuned circuit Q-factor is 130. (6 marks)

4. (a) (i) Table 1 shows the performance parameters of two antennas. State, with reason, which antenna is suitable for:

I. satellite communication
II. radiation of medium wave signals.

Table 1

Antenna	3dB Beam width	Gain (dB)
A	1°	60
B	120°	0

(ii) With the aid of a labelled diagram, describe the operation of a 4-element broadside antenna array. (12 marks)

(b) A radiating antenna, 2 m long, has a radiation resistance of 75 Ω 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 pathloss. (8 marks)

5. (a) (i) List any **two** services provided by satellite communication systems.
(ii) Explain programmed tracking as applied to an earth satellite station antenna. (5 marks)

(b) Draw a labelled block diagram of a 6/4 GHz satellite transponder and describe its operation. (7 marks)

(c) (i) Describe the services provided by Inmarsat.

(ii) A space satellite, located 36,000 km above the earth surface radiates 20 W using an antenna whose gain is 18dB.
The receiving earth station antenna has an effective aperture of 14 m^2.
Determine the:

I. power flux density at the earth station;
II. received power. (8 marks)

6. (a) (i) List any **two** advantages of waveguides over coaxial cables when used in micro wave systems.

(ii) With the aid of a labelled diagram, explain how impedance matching is achieved in waveguides using capacitive irises. (6 marks)

(b) With the aid of a labelled construction diagram, describe the operation of a ruby crystal maser amplifier. (7 marks)

(c) A waveguide, with an internal width of 5 cm, has a characteristic impedance of 600 Ω when the signal carried is the dominant $TE_{1,0}$ mode. Determine the:

(i) cut-off wavelength;
(ii) signal wavelength;
(iii) phase velocity. (7 marks)

7. (a) (i) List any **two** advantages of the star topology over the ring topology data networks.

(ii) With the aid of a labelled diagram, describe the operation of a 4-terminal star data network. (7 marks)

(b) Draw a labelled block diagram of a Pulse Code Modulation (PCM) transmitter and describe its operation. (7 marks)

(c) A data communication system has a dynamic range of 60 dB when transmitting an a.f. signal of 6 sin 600 π t V. Determine the:

(i) number of bits in the transmitted data;
(ii) signal-to-quantisation noise ratio;
(iii) nyquist rate. (6 marks)

8. (a) (i) State any **two** advantages of optic fiber over coaxial cables.

(ii) With the aid of a labelled diagram, describe the transmission of light rays through a graded index optic fiber cable. (7 marks)

(b) Table 2 shows data for an optical sensor.

(i) Plot the response curve.

(ii) Determine the:

I. transmission spectrum;

II. frequencies at which the output power is 55μW;

III. output power at 425 THz. (9 marks)

Table 2

Frequency (THz)	100	150	200	250	300	350	400	450	500	600
Output power (μW)	5	28	44	61	80	94	86	72	40	10

(c) An optical fiber has a core whose refractive index is 1.82 and cladding of refractive index of 1.64. The signal carried by the fiber has a wavelength of 0.70μm.

Determine the:

(i) signal frequency

(ii) numerical aperture. (4 marks)

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