2207/303
COMMUNICATION AND NAVIGATION SYSTEMS
June/July 2019
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:
Non-programmable scientific calculator;
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 indicated.
Candidates should answer the questions in English.

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.

1. (a) (i) List **two** functions of the r.f. stage of a radio receiver.

(ii) With the aid of a circuit diagram, describe the operation of a parallel i.f. trap in a radio receiver.

(6 marks)

(b) Table 1 shows data for an AM receiver selectivity:

Frequency (kHz)	500	600	700	800	900	1000	1100	1200	1300
Output voltage (mV)	0	5.5	15	32.5	46	40	15	5	0.5

(i) Plot the response curve.

(ii) Determine the:

(I) resonant frequency;

(II) output voltage at 1070 kHz.

(7 marks)

(c) An FM radio receiver is tuned to a signal voltage of $6\cos 196\pi \times 10^6 t$ volts and has a local oscillator whose signal voltage is $4\cos 217.4\pi \times 10^6 t$ volts. Determine the:

(i) intermediate frequency;

(ii) image signal frequency.

(7 marks)

2. (a) Define each of the following with respect to Pulse Code Modulation (PCM):

(i) quantisation noise;

(ii) resolution;

(iii) dynamic range.

(3 marks)

(b) (i) With the aid of a response curve, explain non-linear quantisation in PCM).

(ii) A data error detection system uses even parity for the data words 0000_2 to 1111_2. Draw the truth table showing the parity bits.

(10 marks)

(c) An a.f. signal $6\sin 6\pi \times 10^6 t$ volts, is transmitted by PCM using 512 coding levels. Determine the:

(i) Nyquist sampling rate;

(ii) number of bits used;

(iii) signal-to-quantisation noise ratio in dB.

(7 marks)

3. (a) (i) List **two** causes of signal attenuation in waveguides.

(ii) Figure 1 shows a diagram of a directional coupler used to link signals between two waveguides. Explain its operation. (5 marks)

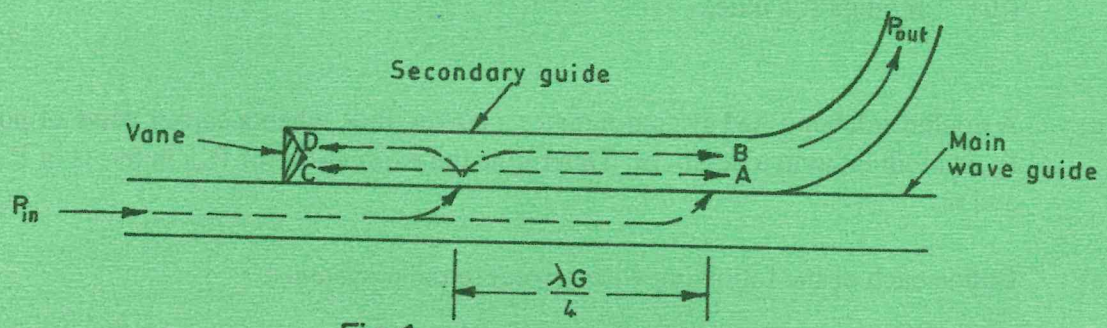

Fig. 1

(b) With the aid of a labelled block diagram, describe the operation of a parametric amplifier. (7 marks)

(c) A rectangular waveguide with the dimensions 3 cm × 4.5 cm, operates at 7.5 GHz when carrying the $TM_{1,1}$ mode. Determine the:

(i) cut-off wavelength;

(ii) waveguide impedance;

(iii) group velocity.

(8 marks)

4. (a) (i) List **two** requirements of a radio transmitter.

(ii) Draw a labelled block diagram of a direct FM transmitter and describe its operation.

(8 marks)

(b) A transistor reactance modulator uses an oscillator whose capacitance is 12 pF and inductance is 3 nH. When a modulating signal of 15 MHz is applied, the effective capacitance increases by 3 pF. Determine the:

(i) carrier frequency;

(ii) frequency deviation of the FM signal;

(iii) modulation index.

(7 marks)

(c) A double sideband AM system radiates a power, P_{out}, when a carrier wave of power, P_c, is modulated to a depth, m. Determine the expression for P_{out} in terms of P_c and m. (5 marks)

5. (a) Define each of the following with respect to radar systems;

(i) duty cycle;

(ii) range resolution;

(iii) maximum unambiguous range.

(3 marks)

(b) Describe each of the following radar systems:

(i) surveillance radar;

(ii) precision approach radar.

(6 marks)

(c) (i) A 9 GHz radar system uses a parabolic dish antenna of 2 m mouth diameter and 65% efficiency to radiate 200 kW towards a target. The target cross-sectional area is 4 m^2 and the system operates over a bandwidth of 500 kHz with a noise figure of 6 dB. Determine the radar range.

(ii) A pulsed radar system has a pulse repetition time of 750 μS and each pulse has a width of 5 μS. Determine the:

(I) maximum unambiguous range;

(II) duty cycle.

(8 marks)

(d) Explain blind speed as applied to radar systems. (3 marks)

6. (a) (i) Define each of the following as applied to stimulated emission devices:

(I) electroluminance;

(II) modulation.

(ii) With the aid of a labelled diagram, describe the operation of a ruby solid laser. (10 marks)

(b) An optical fibre has a core whose refractive index is 1.78 and cladding whose refractive index is 1.68. Determine the:

(i) numerical aperture;

(ii) critical angle;

(iii) maximum angle of incidence. (6 marks)

(c) With the aid of a refractive index profile and light raypath diagram, describe a step index multi-mode optical fibre. (4 marks)

7. (a) (i) List **two** performance specifications of a space satellite.

(ii) Explain each of the following with respect to an earth satellite station antenna:

(I) step tracking;

(II) program tracking. (8 marks)

(b) With the aid of a labelled block diagram, describe attitude and orbit control of a satellite. (7 marks)

(c) An 8 GHz gosynchronous satellite radiates 500 W using a parabolic dish antenna whose gain is 45 dB with an efficiency of 70%. Determine the gain of the receiving antenna if the minimum received power is 6 μW. (5 marks)

8. (a) (i) List **two** areas of application of a microwave antenna.

(ii) Table 2 shows data for an antenna array:

Table 2

Frequency (MHz)	5	10	15	20	25	30	35	40
Field strength $\left(\frac{mV}{m}\right)$	6	32	55	70	61	40	8	2

(I) Plot the response curve.

(II) Determine the antenna bandwidth.

(7 marks)

(b) With the aid of a labelled diagram, describe the operation of a 4-element end-fire array.
(7 marks)

(c) A 6-dipole broadside array radiates 2 kW at 45 MHz. The signal is received at 140 km away through a path whose attenuation is 35 dB. Determine the:

(i) power flux density at the receive point;

(ii) power received by an antenna whose effective aperture is 18 m^2.

(6 marks)

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$\frac{P_t G_t}{4\pi r^2}$