

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)

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- (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)

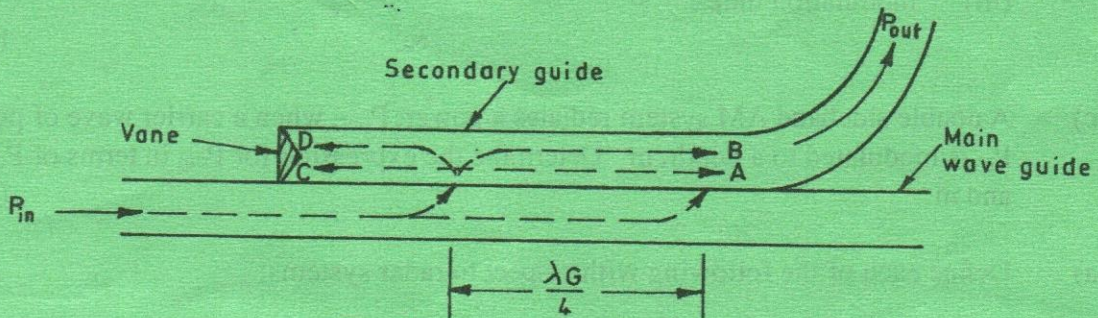


Fig.1

- (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 $3 \text{ cm} \times 4.5 \text{ cm}$, 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)

$$\left(\frac{1}{\sqrt{1 - \left(\frac{f}{f_c}\right)^2}} \right) = v$$

$$v = c \times \sqrt{1 - \left(\frac{f}{f_c}\right)^2}$$

- (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)

- (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 m² 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 μ S and each pulse has a width of 5 μ S. Determine the:

- (I) maximum unambiguous range;
- (II) duty cycle.

$$\frac{cT_{max}}{2} \text{ or } \frac{c}{2\Delta f} = CR$$

$$D = \frac{P_{avg}}{P_p}$$

(8 marks)

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

(3 marks)



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

- (I) electroluminescence;
- (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; *NA = 0.5*
- (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 geosynchronous 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 $6 \mu\text{W}$. (5 marks)



- (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 ($\frac{\text{mV}}{\text{m}}$)	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 m².

(6 marks)

$$P_T = 2 \times 10^3$$

$$f = \frac{c}{\lambda}$$

$$R = 140 \text{ km}$$

$$f_{\text{att}} = f_{\text{att}}$$

$$G_T =$$

$$18$$

$$\Phi =$$

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$$A_P = \frac{A^2 D^2 \eta}{4\pi^2 r^2}$$

$$A_e = \frac{G_r \lambda^2}{4\pi^2}$$

$$P_r = \frac{P_T G_T G_r \lambda^2}{(4\pi r)^2}$$

$$\Phi = \left(\frac{P_T G_T}{4\pi r^2} \right)$$