2207/303
COMMUNICATION AND NAVIGATION SYSTEMS
June/July 2018
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 calculators.
*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.

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.

1. (a) (i) State the **two** functions of the i.f. amplifier stage in a radio receiver.

(ii) With the aid of a labelled block diagram, describe the operation of a double superheterodyre radio receiver. (11 marks)

(b) Figure 1 refers to a radio receiver circuit. If the signal $V_1 = V_1 \sin 1800\pi \times 10^3 t$ volts and $V_2 = V_2 \sin 2710\pi \times 10^3 t$ volts, determine the frequency of the:

(i) output signal;
(ii) image signal. (6 marks)

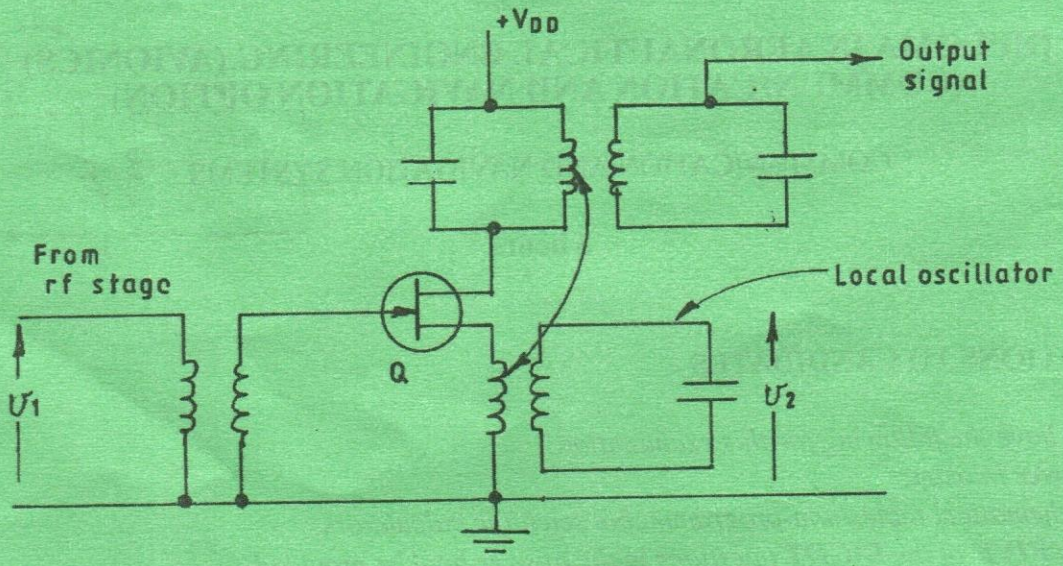

Fig. 1

(c) Explain receiver blocking with respect to a radio receiver. (3 marks)

2. (a) (i) List **two** causes of losses in an antenna.

(ii) Table 1 shows data for an antennna array.

I. Plot the response curve;
II. Determine the change in gain between the 3rd and 6th directors. (6 marks)

Table 1

Number of Directors	0	1	2	3	4	5	6	7
Gain (dB)	1.8	4.1	6	7.4	8.1	8.6	8.9	9

(b) A 4-element folded dipole Yagi antenna array operates at 750 MHz. Draw the array showing all the dimensions. (10 marks)

(c) The magnetic field, H, of a transverse electromagnetic radio wave radiated by an antenna is given by:

$$H = \frac{Idl}{4\pi}\sin\theta\left[\frac{\omega}{CD}\cos\omega\left(t-\frac{D}{C}\right)+\frac{1}{D^2}\sin\omega\left(t-\frac{D}{C}\right)\right] {}^{At}/_{M}$$

Explain the **two** fields forming the wave. (4 marks)

3. (a) Explain the following as applied to radio navigation aids:

(i) surveillance radar equipment;
(ii) precision approach radar. (6 marks)

(b) With the aid of a labelled diagram, describe the operation of an Instrument Landing System (ILS). (7 marks)

(c) A 7 GHz radar system operating over a bandwidth of 800 kHz, uses an amplifier whose noise figure is 12 dB. If the target cross-sectional area is 4 m^2 and the antenna diameter is 1.5 m, determine the radiated power over a range of 60 km. (7 marks)

4. (a) Describe frequency division multiple access (FDMA) with respect to satellite communication. (3 marks)

(b) With the aid of a labelled block diagram, describe the operation of the power subsystem of a space satellite. (6 marks)

(c) (i) An earth station operating at 6 GHz uses an antenna whose mouth diameter is 24 m with an efficiency of 68%. If the system noise temperature is 82 K, determine the earth station ${}^{G}/_{T}$ ratio.

(ii) Determine the free space pathloss (in dB) for a satellite link operating at 600 MHz if the link is 36,000 km long. (11 marks)

5. (a) (i) List **two** advantages of the star network topology over the ring topology.

(ii) With the aid of labelled diagrams, distinguish between half-duplex and full-duplex data transmission modes. (8 marks)

(b) With the aid of a response curve, explain slope overload distortion as applied to delta modulation systems. (4 marks)

(c) An a.f. signal $6\sin 3\pi \times 10^{6}t$ volts is transmitted by Pulse Code Modulation using 512 coding levels. Determine the:

(i) number of bits required;
(ii) signal-to-quantization noise ratio;
(iii) Nyquist sampling rate. (8 marks)

6. (a) (i) List **two** merits of optical fibers over coaxial cables.

(ii) I. Draw a labelled block diagram of an optical fiber communication system.

II. Describe the operation of the system in (a)(ii)(I.) (10 marks)

(b) With the aid of a labelled construction diagram, describe the operation of a photodiode. (6 marks)

(c) An optical fiber has a core of refractive index of 1.72 and cladding refractive index of 1.60. Determine the:

(i) critical angle;
(ii) maximum angle of incidence. (4 marks)

7. (a) (i) Define each of the following as applied to waveguides:

I. phase velocity;
II. cut-off wavelength;

(ii) Figure 2 shows the input waveforms to a parametric amplifier.

I. Draw the output signal.
II. Describe its shape. (6 marks)

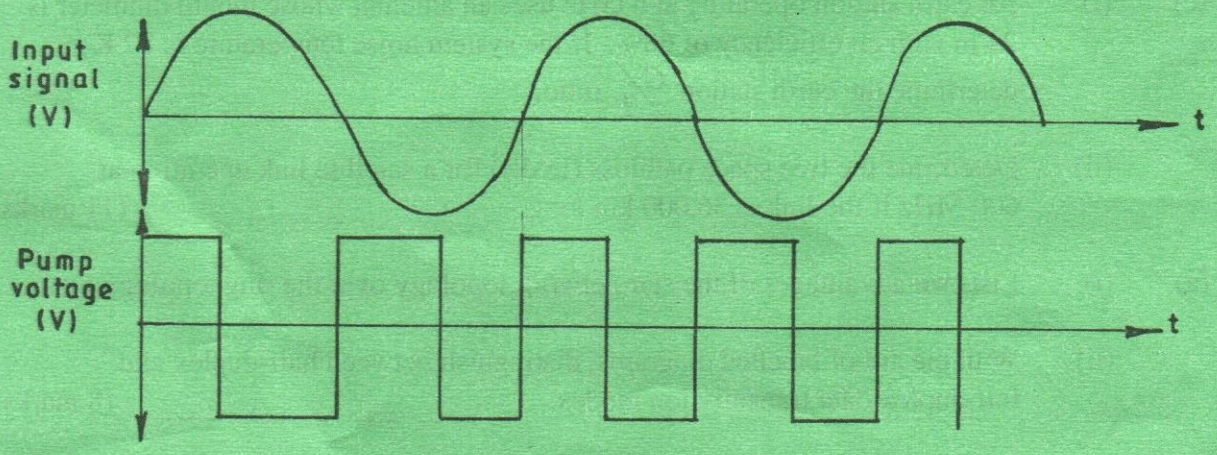

Fig. 2

(b) With the aid of a labelled diagram, describe the operation of a laser diode. (7 marks)

(c) The internal dimensions of a rectangular waveguide, operating at 18 GHz, are 0.85 cm x 0.4 cm. Determine the:

(i) cut-off wavelength;
(ii) group velocity;
(iii) wave impedance. (7 marks)

8. (a) (i) Define each of the following with respect to radio transmitters:

I. efficiency in amplitude modulation systems:
II. modulation index in frequency modulation systems.

(ii) With the aid of a labelled block diagram, describe the operation of a sideband drive unit used to generate an independent sideband signal. (8 marks)

(b) The parameters of an FM system are:
Modulation index = 8
Bandwidth = 170 kHz

Determine the frequency deviation. (4 marks)

$B_{FM} = 2(\delta f + f_m)$

(c) A varactor diode frequency modulator has a self capacitance of 60 pF with the tuned circuit capacitance being 220 pF. If the transmission frequency is 92 MHz, determine the:

(i) tuned circuit inductance;
(ii) change in diode capacitance when the transmission frequency is changed to 95 MHz. (8 marks)

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