2207/303
COMMUNICATION AND NAVIGATION SYSTEMS
Oct./Nov. 2010
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/scientific calculator.

Take: Free space wave velocity, $V_c = 3 \times 10^8 m/s$
Boltzman's constant, $K = 1.38 \times 10^{-23} J/^oC$.

Answer any ***FIVE*** *of the* ***EIGHT*** *questions in this paper.*
All questions carry equal marks.
Maximum marks for each part of a question are as shown.

This paper consists of 5 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) 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 a monopulse radar antenna tracking system. (6 marks)

(c) (i) An 8GHz short-range radar system uses an r.f. amplifier with a noise figure of 4dB and a bandwidth of 400kHz. If the antenna diameter is 0.5m and the target cross-sectional area is $5m^2$, determine the radar range if the peak transmitted power is 5kW.

(ii) A 6.3GHz radar system scans a target over a range of 1000km in 32 seconds. Determine the Doppler frequency shift of the system. (8 marks)

2. (a) Define the following with respect to satellite communications:

(i) perigee;
(ii) frequency re-use. (2 marks)

(b) Draw a labelled block diagram of a $^{14}/_{11}$ GHz satellite transponder and describe its operation. (8 marks)

(c) (i) From first principles, show that the power received (P_R), by an antenna of gain G_R from a radiating antenna of gain, G_T, radiating a power, P_T, over a distance, R, at a frequency, f, is given by:

$$P_R = P_T G_T G_R \left(\frac{\lambda}{4\pi R}\right)^2 \text{ watts.}$$

(ii) An earth satellite station antenna with a diameter of 32m has an illumination efficiency of 82%. If the antenna operates at 6 GHz with a noise temperature of 90K, determine the gain-to-noise temperature (G/T) ratio for the station, in dB/K. (10 marks)

3. (a) (i) List any **two** merits of Frequency Modulation (FM) systems over Amplitude Modulation (AM) systems.

(ii) With the aid of a labelled block diagram, describe the operation of an FM stereo encoder. (8 marks)

(b) A double sideband AM signal is produced when a carrier signal of amptitude 'E_c' is amptitude modulated to a depth 'm' through a resistor R. Derive the expression for the signal transmission efficiency of the system.

(6 marks)

(c) A varactor diode frequency modulator has a capacitance of 60pF with the tuned circuit capacitance being 220pF. If the transmission frequency is 94MHz determine the change in the diode capacitance when the transmission frequency increases to 100MHz. (6 marks)

4. (a) (i) State any **two** factors that determine the fidelity of a radio receiver.

(ii) With the aid of a circuit diagram, explain "ganging and tracking" as applied to a radio receiver. (8 marks)

(b) (i) A radio receiver, with a local oscillator frequency f_o and an intermediate frequency f_i is tuned to a frequency f_s. Derive the expression for the image signal frequency, f_{im}, for the receiver.

(ii) An AM radio receiver has a signal -to-noise ratio of 10dB at the receiver input. If the receiver has a noise figure of 9dB and the bandwidth is 100kHz, determine the signal level required at the receiver input when the résistance is 75Ω. (8 marks)

(c) An FM radio receiver, tuned to 98MHz, is subjected to an image signal at 124MHz. If its image rejection ratio is 45dB, determine the Q - factor of its tuning circuits. (4 marks)

5. (a) Define the following with respect to antennas:

(i) efficiency;
(ii) gain;
(iii) effective isotropic radiated power. (3 marks)

(b) With the aid of a circuit diagram, describe the operation of a 300Ω / 75 Ω balun transformer. (5 marks)

(c) (i) Show that the power gain, Ap , of a microwave antenna is given by:
$Ap = 6.4\left(\frac{D}{\lambda}\right)^2$ for an efficiency of 65%; where:

D = mouth diameter, m
λ = wavelength, m

(ii) A 6GHz microwave antenna has a mouth diameter of 12m and efficiency of 70%.
Determine the:

I beamwidth at the 3dB points;
II effective aperture. (12 marks)

6. (a) (i) State any **two** causes of attenuation in waveguides.

(ii) With the aid of a block schematic diagram describe the operation of a tunnel diode amplifier. (9 marks)

(b) (i) A parallel-plane wave propagates in a waveguide with a group velocity, V_G, at an incident angle of θ. Derive the expression for the group velocity in terms of the velocity of free space, V_c, the cut-off wavelength, λc and free space wavelength, λ.

(ii) The internal width of a rectangular waveguide propagating a $TE_{1,0}$ mode, at a frequency of 12GHz, is 8 cm. Determine the:

I cut-off frequency;
II waveguide wavelength. (11 marks)

7. (a) (i) List any **three** demerits of optical fibres over coaxial cables.

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

(b) Draw a labelled block diagram of an optical fiber communication system and describe it's operation. (8 marks)

(c) An optical fiber cable has a core refractive index of 1.8 and a numerical aperture of 0.18. Determine the:

(i) refractive index of the cladding;

(ii) critical angle of incidence. (4 marks)

8. (a) Define the following as applied to data communications:

(i) dynamic range;
(ii) resolution. (2 marks)

(b) (i) 4 - bit words from 0000_2 to 1111_2 were transmitted using odd parity coding.
Draw the complete truth table, including the parity bits for the transmission.

(ii) With the aid of a response curve, explain how the signal-to-quantization noise (S/N_q) ratio varies with the sampling frequency in Pulse Code Modulation (PCM). (8 marks)

(c) (i) A PCM system uses 128 coding levels to convey a signal $2\sin 5000\pi t$ volts.

Determine the:

I minimum sampling frequency;
II quantization error voltage;
III signal-to-quantization noise ratio.

(ii) Determine the number of bits required to satisfy the dynamic range specification of 58dB for the PCM system in c(i).

(10 marks)