2207/303 COMMUNICATION AND NAVIGATION SYSTEMS Oct./Nov. 2009

Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN AERONAUTICAL ENGINEERING AVIONICS

(COMMUNICATION AND NAVIGATION SYSTEMS OPTION)

COMMUNICATION AND NAVIGATION SYSTEMS

3 hours

INSTRUCTIONS TO CANDIDATES

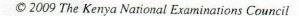
You should have the following for this examination: Answer booklet; Mathematical tables/calculator. Geometrical set

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.

Take: Free space wave velocity, $c = 3x10^8 m/s$

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.



1. (a) (i) List any two factors that determine the sensitivity of a radio receiver. (ii) With the aid of a response curve, explain how selectivity of a radio receiver is determined. (6 marks) (b) Show that for an envelope detector, the time constant RC of detector load is given by: $RC \leq \frac{\sqrt{(1-m^2)}}{m\omega_m}$ where: m = depth of modulation ω_{m} = angular velocity of modulating signal. (8 marks) An AM radio receiver with an intermediate frequency of 455 KHz is subjected to an (c) image frequency of 24.5MHZ. If it has an image frequency rejection ratio of 22dB, determine the: I. frequency to which it is tuned; II. Q-factor of its coupling circuit. (6 marks) 2. (a) (i) Define the following with respect to satellite communications: I. minor axis; II. footprint; III. geosynchronous orbit. (ii) Draw a labelled block diagram of a satellite sub-system consisting of telemetry, tracking and command stages and describe its operation. (9 marks) Describe "auto tracking" as applied to an earth satellite station antenna. (b) (i) (ii) An 11GHz satellite station located 36,000 km above the earth surface radiates 5W using an antenna of 22dB gain. If the receiving antenna has an effective aperture of 12m² and a gain of 55dB, determine the: power flux density at the receiving point; II. received power. (11 marks) State any three advantages of a continuous wave radar over a pulsed radar (a) (i) system. (ii) With the aid of a labelled diagram, describe "lobe-switching" as applied to radar

(8 marks)

antenna tracking.

- (b) (i) Describe the application of marker beacons with respect to instruments landing systems.
 - (ii) An aircraft with a relative velocity Vr is approaching a stationary radar antenna. If the antenna is operating at a frequency of f_t, derive an expression for the Doppler frequency shift. (6 marks)
- (c) A 750MHz radar system, operating over a range of 10Km, produces a minimum receivable power of 250pW. If the antenna capture area is 5m² and the target cross-sectional area is 14m², determine the:
 - (i) peak pulse power radiated;
 - range over which a radiated power of 10Kw will produce a minimum receivable power of 1200pW. (6 marks)
- 4. (a) Define the following as applied to antennas:
 - (i) polar diagram;
 - (ii) front-to-back ratio.

(2 marks)

- (b) (i) With the aid of a labelled diagram, describe the operation of a rhombic antenna.
 - (ii) The data in table 1 refers to a receiving antenna. Plot the polar diagram of the radiation pattern and hence determine the 3dB beamwidth.

Angular Displacement (0)	-35	-30	-25	-20	-15	-10	-5	0	+5	÷10	+15	+20	+25	+30	+35
Field strength (m V/m)	0	22	23	25	28	30	33	35	28	25	22	18	16	13	0

Table 1

(11 marks)

- (c) A radiating antenna, 1.5m long, has a resistance of 50Ω and a power gain of 20dB towards a receiver 60Km away. If the antenna is supplied with a current of 0.5Amps, determine the:
 - (i) electric field strength at the receiver;
 - (ii) maximum received power;
 - (iii) transmission pathloss.

(7 marks)

5. State any two applications of a varactor diode in communication systems. (a) (i) With the aid of a circuit diagram, describe the operation of a transistor push-pull (ii) double sideband suppressed carrier (DSBSC) modulator. An additive transistor mixer is driven by the signals $V_b = V_1 \sin \omega_1 t$ (b) volts and $V_e = V_2 Sin\omega_2 t$ Volts. Derive an expression for the output current of the mixer. (5 marks) An FM modulator, with no audio input signal, has an output of 15MHz at an amptitude (c) of 5V. If applying an audio signal, $V_m = 1.5 \text{ Sin } 6280t \text{ volts}$, produces a frequency deviation of 30KHz: derive an expression for the FM wave; (i) (ii) determine the peak phase deviation of the FM wave. (7 marks) 6. List any two applications of cavity resonators in communication systems. (a) (i) With the aid of a labelled block diagram, describe the operation of a (ii) parametric amplifier. (10 marks) With the aid of a labelled diagram, explain how a capacitive wave guide (b) (i) iris is used in impedance matching. A rectangular waveguide measuring 4cm x 2cm in dimension has a signal of (ii) 10GHz propagated in it. For the TM_{1,1} mode, determine the: I. cut-off wavelength; II. phase velocity: characteristic wave impedance. III. (10 marks) 7. (a) State any two performance characteristics required of optical detectors. (i) With the aid of a light raypath diagram, describe the operation of a monomode (ii) optical fiber. (6 marks) Draw a labelled construction diagram of a photo-diode and describe its operation. (b) (6 marks) A microwave repeater antenna has a mouth diameter of 12m and operates at 9.5GHz. (c) If its illumination efficiency is 0.7, determine its: directivity (in dB); (i) (ii) beamwidth at the nulls. (8 marks) 8. Draw a labelled block diagram of a 4 - channel TDM/PCM telephone communication (a) system and describe its operation. (7 marks) 2207/303

4

- (b) (i) With the aid of a waveform, explain "slope overload distortion" as applied to Pulse Code Modulation (PCM).
 - (ii) A PCM system is fed with a 4 channel speech of frequencies 0 to 4KHz which is quantized into 128 levels. Determine the minimum bit rate required by the system to avoid distortion. (9 marks)
- (c) The bit rate of a pulse modulation system is 8Kbits/sec when the signal-to-noise ratio is 0.001. Determine the system bandwidth. (4 marks)