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)

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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)

(c) An AM radio receiver with an intermediate frequency of 455 KHz is subjected to an 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)

(b) (i) Describe "auto tracking" as applied to an earth satellite station antenna.

(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 $12m^2$ and a gain of 55dB, determine the:

I. power flux density at the receiving point;
II. received power. (11 marks)

3. (a) (i) State any **three** advantages of a continuous wave radar over a pulsed radar system.

(ii) With the aid of a labelled diagram, describe "lobe-switching" as applied to radar antenna tracking. (8 marks)

(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 $5m^2$ and the target cross-sectional area is $14m^2$, determine the:

(i) peak pulse power radiated;
(ii) 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. (a) (i) State any **two** applications of a varactor diode **in** communication systems.

(ii) With the aid of a circuit diagram, describe the **operation** of a transistor push-pull double sideband suppressed carrier (DSBSC) **modulator**. (8 marks)

(b) An additive transistor mixer is driven by the signals $V_b = V_1 Sin\omega_1 t$ volts and $V_c = V_2 Sin\omega_2 t$ Volts. Derive an expression **for** the output current of the mixer.

(5 marks)

(c) An FM modulator, with no audio input signal, has an **output** of 15MHz at an amptitude of 5V. If applying an audio signal, V_m = 1.5 Sin 6280t **volts**, produces a frequency deviation of 30KHz:

(i) derive an expression for the FM wave;

(ii) determine the peak phase deviation of the FM **wave**. (7 marks)

6. (a) (i) List any **two** applications of cavity resonators in **communication** systems.

(ii) With the aid of a labelled block diagram, describe **the** operation of a parametric amplifier. (10 marks)

(b) (i) With the aid of a labelled diagram, explain how a **capacitive** wave guide iris is used in impedance matching.

(ii) A rectangular waveguide measuring 4cm x 2cm **in** dimension has a signal of 10GHz propagated in it. For the $TM_{1,1}$ mode, **determine** the:

I. cut-off wavelength;
II. phase velocity;
III. characteristic wave impedance. (10 marks)

7. (a) (i) State any **two** performance characteristics required **of** optical detectors.

(ii) With the aid of a light raypath diagram, describe **the** operation of a monomode optical fiber. (6 marks)

(b) Draw a labelled construction diagram of a photo-diode and describe its operation. (6 marks)

(c) A microwave repeater antenna has a mouth diameter of 12**m** and operates at 9.5GHz. If its illumination efficiency is 0.7, determine its:

(i) directivity (in dB);

(ii) beamwidth at the nulls. (8 marks)

8. (a) Draw a labelled block diagram of a 4 - channel TDM/PCM **telephone** communication system and describe its operation. (7 marks)

(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)