2207/303
COMMUNICATION AND NAVIGATION SYSTEMS
Oct./Nov. 2008
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/Calculator
Smith chart

*Answer any **FIVE** of the following **EIGHT** questions.*
All questions carry equal marks.

This paper consists of 5 printed pages.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and no questions are missing.

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1. (a) (i) State any **two** merits of the phasing method over the filter method of generating a single sideband (SSB) signal.

(ii) Define "transmission efficiency" as applied to an amplitude-modulated (AM) transmitter. (3 marks)

(b) (i) Draw a labelled block diagram of the phase-shift lower SSB modulator and describe its operation.

(ii) If the a.f. signal is $V_m Sin(\omega_m t)$, derive the expression for the modulator output in b (i). (11 marks)

(c) An AM transmitter radiates 10kw when modulated to 80%. Determine the sideband powers (in dBW) for the following systems:-

(i) double sideband;
(ii) single sideband suppressed carrier. (6 marks)

2. (a) Define the following with respect to radio receivers:

(i) selectivity;
(ii) image rejection ratio;
(iii) blocking. (3 marks)

(b) (i) With the aid of a circuit diagram, describe the operation of a FET mixer.

(ii) With the aid of a response curve, describe the function of an amplitude limiter in an FM radio receiver. (11 marks)

(c) A radio receiver is tuned from 1400KHZ to 700kHZ when the r.f. capacitance varies from 50pF to 200pF and the local oscillator capacitance varies from 120pF to 360pF. If the i.f. is 450KHz, determine:

(i) the frequency to which the receiver is tuned when the r.f. capacitance is 210pF;

(ii) the local oscillator capacitance when the local oscillator frequency is 1150KHz. (6 marks)

3. (a) (i) List any **two** sources of losses in a microwave antenna.
(ii) Draw a labelled diagram of a 5 - element end-fire antenna array and describe its operation. (7 marks)

(b) A transmission line, of 0.05S admittance, is terminated by a load of 0.025 + j0.04S admittance. Using the Smith chart provided, determine the length and position of a single stub used to match the load to the line. (7 marks)

(c) A troposcatter link antenna of 23dB gain, radiates 50kW at 30 MHz towards another antenna of 26dB gain. If the link is 1000km long with pathloss of 100dB more than free space loss, determine the received power. (6 marks)

4. (a) (i) State any **two** areas of application of Lasers in communication systems.

(ii) Draw a labelled construction diagram of a laser diode and describe its operation. (7marks)

(b) With the aid of a labelled block schematic diagram, explain the operation of a microwave transmit/receive switch using PIN diodes. (7 marks)

(c) A rectangular waveguide, measuring 2.5cm by 5 cm, carries a signal of 6GHZ. For the $TM_{1,0}$ mode, determine:

(i) the cut-off wavelength;
(ii) the group velocity;
(iii) characteristic wave impedance. (6 marks)

5. (a) Define the following as applied to satellite communications:

(i) apogee;
(ii) latency;
(iii) station keeping. (3 marks)

(b) Draw a labelled block diagram of a satellite attitude and orbit control subsystem and describe its operation. (6 marks)

(c) (i) Derive an expression for the satellite link pathloss in dB.
(ii) A 4.15GHz earth satellite station uses a 30m diameter antenna of 68% efficiency. If the system noise temperature is 79K, determine:

I. the earth station G/T ratio;
II. the new G/T ratio if heavy rain causes sky temperature to raise the system noise temperature to 88K.

(11 marks)

6. (a) (i) State any **two** merits of Pulse Code Modulation (PCM) over other modulation methods.

(ii) With the aid of labelled diagrams, distinguish between a half-duplex and a full-duplex transmissions. (6 marks)

(b) (i) Draw a labelled block diagram of a 4-channel synchronous TDM data multiplexer and describe its operation.

(ii) With the aid of a labelled diagram, describe a 7-segment common-anode display unit. (10 marks)

(c) Determine the channel capacity for data transmission system with a signal-to-noise ratio of 36dB and a spectrum between 2MHZ and 4 MHZ. (4 marks)

7. (a) (i) List any **two** areas of application of optical fibers.

(ii) With the aid of a lightwave raypath diagram, describe the step index optical fiber. (5 marks)

(b) (i) Draw a circuit diagram of a photodiode opto-coupler and describe its operation.

(ii) Determine:

I the numerical aperture (N.A) of an optical fiber whose cladding refractive index is 1.8 and for the core is 1.2 respectively;

II the wavelength of a single mode optical fiber whose operating velocity is 2.04×10^8m/s at a frequency of 193.4THz. (8 marks)

(c) With the aid of an input waveform and the Applegate diagram, describe the operation of a two-cavity klystron amplifier. (7 marks)

8. (a) (i) State any **two** areas of application of radar systems.

(ii) Derive an expression for the radar range equation in terms of the antenna constants, radiated power, and frequency. (10 marks)

(b) (i) Draw a labelled diagram of a radar A scope display and describe its operation.

(ii) A 7GHz radar system, operating over a 600KHz bandwidth, uses an amplifier of 5dB noise figure.
If the target cross-sectional area is $6m^2$, determine the radiated power over an 18km range with an antenna of 1.5m mouth diameter. (10 marks)

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IMPEDANCE OR ADMITTANCE COORDINATES