2203/306
COMMUNICATION SYSTEMS
Oct./Nov. 2010
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN TELECOMMUNICATION ENGINEERING

COMMUNICATION SYSTEMS

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Mathematical tables/Scientific calculator.
Smith Chart.

Take: Earth radius R = 6400Km
Boltzam's constant, k = 1.38 x 10 10^{-23} J/^{0}C
Free space wave velocity, C = 3 x 10^8 m/s

*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 6 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) Define the following as applied to transmission lines:
   (i) attenuation coefficient;
   (ii) group velocity. (2 marks)

   (b) When a voltage $\sqrt{2}\cos(\pi \times 10^8 t)$ volts is applied at the input of a lossless infinite line, the current flowing is $12.5\sqrt{2}\ cos(\pi \times 10^8)t\ mA$.

   (i) derive an expression for the voltage $3\lambda/4$ away from the input;
   (ii) determine the input:
      I power;
      II impedance. (8 marks)

   (c) (i) An 800Hz signal undergoes a 45^0 phase change over a 9km transmission line. Determine the signal phase velocity.

   (ii) An air dielectric transmission line has a characteristic admittance of 0.0025S at a frequency of 100MHz and is terminated by a load whose admittance is 0.005 - j0.003S. Using the Smith chart provided, determine the length of a short-circuited line required to remove the susceptance. (10 marks)

2. (a) (i) Sketch the electric and magnetic fields in:

      I. a pair of parallel lines carrying currents in opposite directions;
      II. a coaxial cable situated away from any other conductors.

   (ii) With the aid of a labelled diagram, describe the operation of a circulator transmit/receive switch in microwave systems. (9 marks)

   (b) With the aid of a raypath signal diagram, derive an expression for the group wavelength, λ_G, of a waveguide in terms of the signal wavelength, λ, and guide width, a. (6 marks)

   (c) A rectangular waveguide, 0.85cm wide, operates at 20GHz when carrying the dominant mode.
   Determine the :
   (i) cut-off frequency;
   (ii) characteristic wave impedance. (5 marks)

3. (a) (i) Explain "effective earth radius" as applied to propagation of radio waves.
   (ii) With the aid of a labeled diagram, describe "trapping" with respect to propagation of radio waves. (8 marks)

(b) From the Snell's law governing a skywave;

$n = \frac{\sin \phi i}{\sin \phi r} = \sqrt{(1 - \frac{fc^2}{fmu^2})}$, derive the Secant law.

where: ϕi = angle of incidence.
ϕr = angle of refraction.
fc = critical frequency, Hz.
f_{mu} = max^m usable frequency, Hz. (5 marks)

(c) A High Frequency (HF) communication link uses the E - layer with maximum electron density of 1.5 x 10^{11} electrons/m^3 and it is at a virtual height of 150Km. Determine the maximum:
(i) usable frequency;
(ii) single-hop range. (7 marks)

4. (a) Define the following as applied to antennas:
(i) illumination efficiency;
(ii) effective aperture. (2 marks)

(b) (i) Draw a labelled diagram of a 4 - element stacked dipole antenna array and describe its operation.

(ii) With the aid of a labelled diagram, describe the operation of a microwave dish antenna using cassegrain feed method. (10 marks)

(c) A parabolic reflector antenna of mouth diameter 15m, operates at 8GHz. If the illumination efficiency is 75%, determine the:
(i) directivity in dB,
(ii) beamwidth at the nulls. (8 marks)

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

I. noise figure;
II. receiver blocking.

(ii) With the aid of a labelled block diagram, describe the operation of a Frequency Modulation (FM) stereo decoder. (8 marks)

(b) An AM radio receiver with an i.f of 465kHz, encounters an image signal of 1730kHz. If the image rejection ratio is 32dB, determine the:

(i) signal frequency;

(ii) coupling circuit Q-factor. (6 marks)

(c) An FM radio receiver amplifier has a noise figure of 12 dB, a gain of 50 dB and an equivalent noise bandwidth of 15kHz. Determine the:

(i) effective noise temperature at 17°C;

(ii) available output noise power when the input is terminated in a matched source resistance whose noise temperature is 290K. (6 marks)

6. (a) (i) List any **three** methods of increasing the maximum usable range in pulsed radar systems.

(ii) With the aid of waveforms, explain how the Doppler effect is used in an FM continuous wave radar to perform range measurements. (10 marks)

(b) A moving target indicator radar operates at 8GHz with a pulse repetition frequency of 800 pulses per second. Determine its's two lowest blind speeds. (4 marks)

(c) With the aid of a transmission signal frequency spectrum, describe a colour TV picture signal. (6 marks)

7. (a) (i) List any **two** characteristics that determine the performance of a satellite earth station.

(ii) Draw a labell.ed block diagram of a satellite earth station and describe its operation. (10 marks)

(b) (i) An earth station dish antenna has a diameter of 32m and an illumination efficiency of 82%. If the link operates at 6GHz with a noise temperature of 90K, determine the G/T of the station.

(ii) A space satellite station, operating at 5.8GHz, beams 4kW power using an antenna of gain 24,000. If the earth station receiving antenna, located 50,000km away has a gain of 26, determine the:

I. received power in watts;

II. receive antenna gain that would result in twice the received power. (10 marks)

8. (a) Define the following with respect to modulation systems:
   (i) peak envelope power in single sideband modulation;
   (ii) modulation index in frequency modulation;
   (iii) transmission efficiency in amplitude modulation. (3 marks)

   (b) With the aid of a circuit diagram, describe the operation of a ring modulator. (7 marks)

   (c) A double sideband (DSB) amptitude modulation transmitter drives 15 Amps into an antenna when the depth of modulation is 55%. If simultaneous modulation by another sinewave increases the transmitter current to 16Amps, determine the:

   (i) new depth of modulation;
   (ii) total radiated power;
   (iii) improvement in signal-to-noise ratio, in dB, if an SSBSC system is used. (10 marks)

IMPEDANCE OR ADMITTANCE COORDINATES