2203/306
COMMUNICATION SYSTEMS
Oct./Nov. 2009
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*
- *Calculator*
- *Smith chart*

Take the following constants to be
- *Speed of light* $C = 3.0 \times 10^8$ *m/s*
- *Permeability of a vacuum* $= 4\pi \times 10^{-7}$ *H/m*
- *Permittivity of a vacuum* $= 8.85 \times 10^{-12}$ *F/m*

*Answer any **FIVE** of the **EIGHT** questions in this paper.*
All questions carry equal marks.
Maximum marks for each part of a question are 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) The instantaneous voltage of an FM signal developed across a 75Ω load can be expressed as:

$v(t) = 100 \cos (2\pi\ 10^6 t + 2.4 \cos 2\pi 10^3 t)$ Volts

If the modulating signal has a peak amplitude of 500 mV, determine the:

(i) modulation index;
(ii) maximum frequency deviation;
(iii) modulator sensitivity;
(iv) bandwidth of the FM signal. (8 marks)

(b) (i) With the aid of a circuit diagram, describe the operation of a varactor diode frequency modulator.

(ii) Show that for a direct FM generator the frequency deviation is given by

$\Delta f = \frac{\Delta c}{2c} f_0$

where

f_0 = carrier frequency
c = oscillator capacitance
Δc = change in capacitance (12 marks)

2. (a) (i) State any **one** radar performance characteristic affected by the radar:
I pulse width;
II pulse repetition frequency.

(ii) A radar system has the following performers specifications

Transmitted power	=	250 Kw
cross-sectional area of target	=	12.5 m^2
minimum received power	=	10^{-13}W
receiver antenna gain G_R	=	2000
wavelength λ	=	16 cm

Determine the radar maximum range. (5 marks)

(b) With the aid of a labelled diagram, describe the operation of a Travelling Wave Tube (TWT). (8 marks)

(c) (i) Describe the Plan Position Indicator (PPI) radar display.

(ii) A continuous wave radar system uses a frequency of 3 GHz. If the target velocity is 200 km/h. Determine the doppler frequency seen by a stationary radar. (7 marks)

3. (a) Distinguish between a resonant and a travelling wave antenna, stating an example in each case. (4 marks)

(b) With the aid of a labelled diagram, describe the operation of a 5 - element log periodic antenna. (6 marks)

(c) (i) A parabolic reflector antenna with a reflector diameter of 6m and illumination efficiency of 0.65 operates at a frequency of 10 GHz.

Determine its:

I effective area;
II directivity;
III 3 dB-beam width.

(ii) State the effects of spillover and backlobe radiations in the antenna in c(i). (10 marks)

4. (a) With reference to satellite communications:

(i) describe attitude control;

(ii) explain the:

I reason why a higher frequency is used for uplink and a lower frequency for down-link transmission;
II concept of frequency re-use;
III concept of Code Division Multiple Access (CDMA). (11 marks)

(b) A satellite communication system is to be used to transmit a video signal from earth to satellite. The following specifications are given:

Power of earth station transmitter	= 2200 W
The antenna gain	= 66.3 dB
Free path loss	= 207.5 dB
Satellite figure of merit G/T	= -5.3 dB/K
Atmospheric losses	= 0.6 dB
Boltzman's constant K	= -228 dB/W/k/Hz

Determine the:

(i) earth station EIRP (in dBW);

(ii) uplink carrier to noise density ratio in dB. (9 marks)

5. (a) Explain the importance of the use of the dominant mode in rectangular wave guides. (2 marks)

(b) (i) Figure 1 shows a rectangular waveguide. If a TE_{10} mode is launched in the guide, sketch the field patterns as seen along planes XX' YY' and ZZ'.

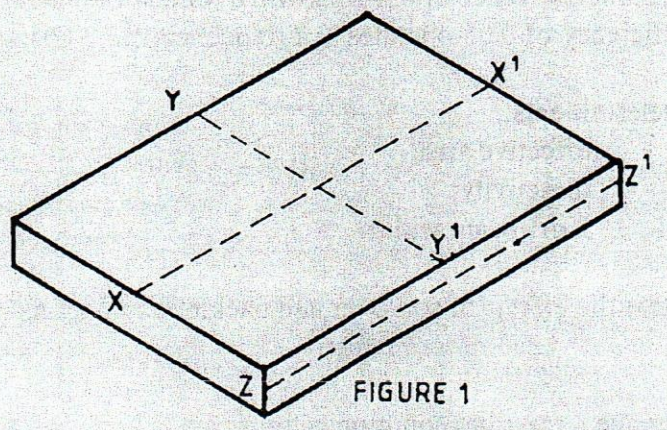

FIGURE 1

(ii) If probe coupling is used in (i), use a labelled diagram to illustrate the position of maximum coupling. (8 marks)

(c) (i) With the aid of diagrams, illustrate the use of inductive and capacitive irises.

(ii) A wave guide of internal dimensions 3 cm by 1.5 cm is energized in the dominant mode by a klystron, the frequency of which is adjusted to make the guide-wavelength exactly 8cm. Determine the klystron's output frequency. (10 marks)

6. (a) State any **three** errors which result from slotted line measurements. (3 marks)

(b) (i) A line operating at 100Mhz has the following distributed constants per metre:

$R = 110\Omega$, $L = 0.25\ \mu H$, $C = 100 pF$ and $G = 0$

Determine the:

I characteristics impedance;
II phase shift coefficient;
III phase velocity.

(ii) Use a Smith chart to determine the position and length of a short-circuited stub to match a load impedance of $450 + j600\Omega$ to a line of 300Ω. (11 marks)

(c) (i) Explain tracking as used in radio receivers.

(ii) A receiver tunes signals from 550 to 1600 khz with an IF of 455 kHz. Determine the frequency tuning range ratio for the oscillator section. (6 marks)

7. (a) Explain **two** causes of fading in sky-wave propagation. (4 marks)

(b) For space wave propagation show that the received electric -field strength E_R at a distance of separation of the antennas d is given by

$$E_R = \frac{2E_0}{d}\sin\left(\frac{2\pi h_T h_R}{\lambda d}\right)$$

where λ is the wavelength of the transmitted wave, h_T and h_R the heights of transmitting and receiving antennas respectively and E_0 is the field strength of the transmitter.

(12 marks)

(c) The average electron density in an ionespheric layer is $N = 5 \times 10^{10}$ electron/m^2. Given that a plane electromagnetic wave of 10 MHz propagates in the ionosphere determine the:

(i) critical frequency, f_c;
(ii) phase shift constant β. (4 marks)

8. (a) With respect to TV transmission, explain **two** advantages of negative modulation over positive modulation. (4 marks)

(b) (i) In the NTSC television standard the number of lines per frame N = 525 and the number of frames per second p = 30.

Determine the:
I horizontal synchronization frequency;
II vertical synchronization frequency;
III time required to scan one line.

(ii) Explain the purpose of the aluminium coating used on the inside of CRT television tubes. (8 marks)

(c) An antenna having a noise temperature of 580K is matched to a pre-amplifier having a noise figure of 2.5 dB and an available power gain of 8dB. This is in turn matched to a receiver having a noise factor of 7 dB and r.f bandwidth of 10 Khz. For this system determine the:

(i) effective noise factor;
(ii) SNR at the output of the receiver.

(8 marks)

IMPEDANCE OR ADMITTANCE COORDINATES