2602/304
ELECTROMAGNETIC FIELDS THEORY
AND COMMUNICATION SYSTEMS
Oct./Nov. 2016
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING (TELECOMMUNICATION OPTION)

MODULE III

ELECTROMAGNETIC FIELDS THEORY AND COMMUNICATION SYSTEMS

3 hours

INSTRUCTIONS TO CANDIDATES

You should have an electronic calculator/mathematical tables for this examination.
*This paper consists of **TWO** sections; **A** and **B**.*
*Answer any **TWO** questions from section **A** and any **THREE** questions from section **B** in the answer booklet provided.*
All questions carry equal marks.
Maximum marks for each part of a question are as shown.
Candidates should answer the questions in English.

Take: electronic charge $e = 1.602 \times 10^{-19}$C
Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m
Permeability of free space, $\mu o = 4\pi \times 10^{-7}$ H/M
Velocity of light $C = 3 \times 10^8$ m/s
Wave impedance of free space £ $= 377\ \Omega$.

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.

Turn over

SECTION A: ELECTROMAGNETIC FIELDS THEORY

*Answer any **TWO** questions from this section.*

1. (a) Define each of the following with respect to electrostatics:

(i) electric field intensity;
(ii) electric flux. (2 marks)

(b) Two points in space are at distances r_A and r_B from a point charge Q located at the origin. Derive an expression for the potential difference, V_{AB}, between these two points. (5 marks)

(c) A charge $Q_1 = 5 \cap C$ is located at P(2,3,5) and another charge $Q_2 = 4 \cap C$ is located at R(3,2,3). Determine the electric field intensity, $\overline{E}$, due to the two charges at point S (6,7,8). (10 marks)

(d) Define each of the following charges:

(i) point charge;
(ii) volume charge;
(iii) line charge. (3 marks)

2. (a) With the aid of a sketch, describe Biot-Savart law of electro-magnetism. (5 marks)

(b) Two parallel wires carry a current of 10 A each. The separation between the wires is 4 cm. Determine the force per unit length on one of the wires. (3 marks)

(c) A 8 GHz plane magnetic wave travelling in the positive Z - direction in a lossless dielectric media with relative permeability $\mu_r = 1$ and relative permittivity, $\varepsilon_r = 3$ has peak electric field intensity, E_{max}, of 16 V/m. For the wave, determine the:

(i) velocity;
(ii) intrinsic impedance;
(iii) peak magnetic field;
(iv) propagation constant, β. (8 marks)

(d) A hollow spherical conductor is immersed into a parallel-lines magnetic field.

(i) Draw the charge distribution and field pattern on the conductor;
(ii) State **one** application to the phenomenon in d(i). (4 marks)

3. (a) State **two** characteristics of electromagnetic waves. (2 marks)

(b) Using Maxwell's equations, derive the expression for poynting theorem. (8 marks)

(c) (i) With the aid of sketches, describe Farady's law of electromagnetism.

(ii) A 10 μC charge is moved from P(0,0,0) to Q(2,-1,4) against an electric field $\overline{E} = 2xyz\ \hat{a}_x + x^2 z\ \hat{a}_y + x^2 y\ \hat{a}_z\ V/m$ via a straight line $x = -2y, z = 2x$.

Determine the total work done in moving the charge. (10 marks)

SECTION B: COMMUNICATION SYSTEMS

*Answer any **THREE** questions from this section.*

4. (a) (i) List **two** merits of using the double sideband suppressed carrier (DSBSC) system in radio wave broadcasting.

(ii) With the aid of a labeled block diagram, describe the operation of a high-level amplitude modulation transmitter. (8 marks)

(b) **Figure 1** shows a varactor diode frequency modulator. Describe its operation. (4 marks)

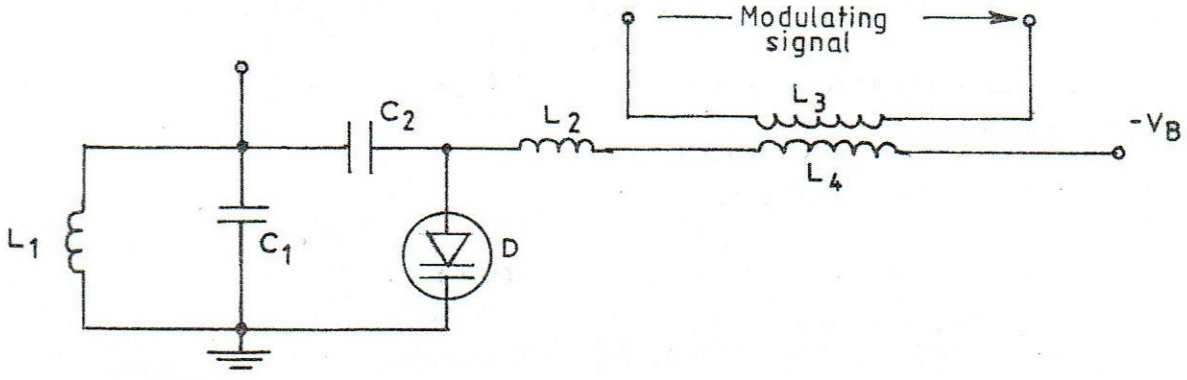

Fig. 1

(c) A transistor reactance modulator uses an oscillator whose capacitance and inductance are 12pF and 4nH respectively. When the modulating signal $v_m = 6\sin 10\pi \times 10^4 t$ is applied, the effective capacitance increases by 3pF. Determine the:

(i) frequency deviation of the oscillator output;
(ii) modulation index (8 marks)

5. (a) (i) List **two** areas of application of a continuous wave radar system.
(ii) With the aid of a labelled block diagram, describe the operation of frequency modulation continuous wave radar.

(9 marks)

(b) A 7 GHz radar system scans a target over a range of 900 km in 45 secs. Determine the Doppler frequency shift for the system. (4 marks)

(c) A pulsed radar system operating at 9 GHz over a bandwidth of 800 kHz, uses an r.f. amplifier with a noise figure of 6 dB and an antenna whose diameter is 2 m. If the target cross-sectional area is 4 m^2 at a range of 150 km, determine the:

(i) radiated power;
(ii) radar range if the radiated power is decreased by 20%. (7 marks)

6. (a) Describe each of the following emerging technologies:
(i) wimax;
(ii) interactive TV. (6 marks)

(b) (i) **Figure 2** shows a Y-circulator microwave switch. Describe its operation.

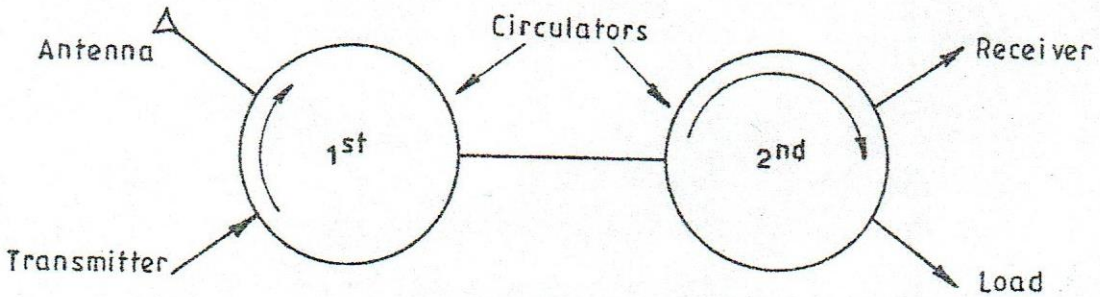

Fig. 2

(ii) With the aid of a labelled diagram, describe the operation of a capacitive wave guide iris. (10 marks)

$\lambda_c = 2a$

(c) A rectangular waveguide, 3 cm wide, carries a signal whose wavelength is 4 cm. For the $TE_{1,0}$ mode, determine the wave impedance. (4 marks)

7. (a) Define each of the following with respect to satellite communications:

(i) footprint;
(ii) apogee. (2 marks)

(b) (i) With the aid of a labelled block diagram, describe the operation of a satellite transponder.

(ii) **Figure 3** shows a star VSAT network. Describe its operation. (10 marks)

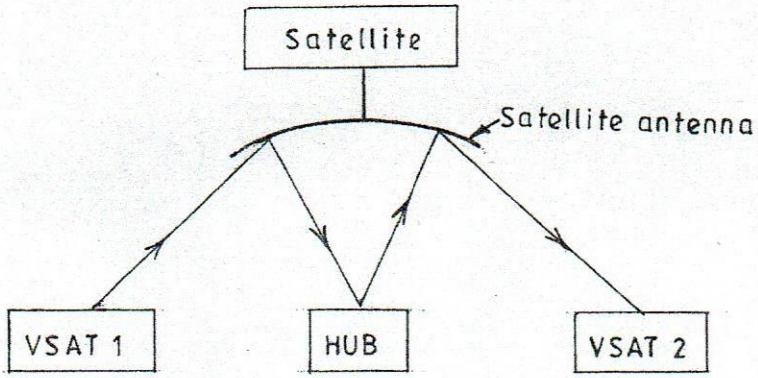

Fig. 3

(c) (i) Explain link budget as applied to satellite communications.

(ii) An earth satellite station operating at 8 GHz, radiates 4 kW towards a space station located 36,000 km away. The radiating antenna has a gain of 60 dB and the receiving antenna, with an efficiency of 70%, receives 5 μW. Determine the gain of the receiving antenna in dB. (8 marks)

8. (a) Define each of the following with respect to TV systems:

(i) line frequency;
(ii) horizontal resolution. (2 marks)

(b) With the aid of a labelled diagram, describe interlaced scanning as applied to PAL TV standard. (6 marks)

(c) The Communications Authority of Kenya allocates frequencies to 24 TV channels in the UHF band starting from 300 MHz. Each channel occupies 6 MHz and there is a 200 kHz guardband between any two channels.

(i) determine the frequencies of the first four channels;
(ii) draw the transmission spectrum for the channels in c(i). (12 marks)

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