MACHAKOS UNIVERSITY

University Examinations for 2023/2024 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

FIFTH YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EEE548: ANTENNA & PROPAGATION

DATE: **TIME:**

INSTRUCTIONS

Attempt question ONE (Compulsory) and any other TWO questions.

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Define the following fading classifications:

i. Rapid fluctuations

ii. Short-term fluctuations

iii. Long-term fluctuations. (3 marks)

b) State THREE applications of Cassegrain feed for parabolic reflector antennas. (3 marks)

c) Briefly explain the effects of atmosphere in space wave propagation. (4 marks)

d) With the aid of suitable sketches differentiate between broadside array and end-fire array in terms of their radiation patterns. (6 marks)

e) A small circular loop of radius 0.5 m is carrying a current of 10 A at 15 MHz. If the loop is symmetrically placed at the origin and in the $x-y$ plane, calculate the magnitude of the electric field intensity in the $x-y$ plane at a distance of 10 km. (5 marks)

f) A voltage source of amplitude $V_g = (50 + j40)$V and a source impedance $Z_g = 50\Omega$ is connected to an antenna having a radiation resistance $R_{rad} = 70\Omega$, loss resistance $R_{loss} = 1\Omega$, and a reactance $jX = j25\ \Omega$. Calculate:

i. The radiation efficiency of the antenna,

ii. The real power input to the antenna,

iii. Power radiated by the antenna, and

iv. Power dissipated in the antenna. (10 marks)

QUESTION TWO (20 MARKS)

a) State pattern multiplication theorem. (3 marks)

b) Show that the directions of maxima of the array factor of a two-element array shown in Figure Q2 (b), with excitations $I_1 = e^{jkd/2}$ and $I_2 = e^{-jkd/2}$ are given by

$$\theta_m = \cos^{-1}\left(\frac{\pm 2m\pi + kd}{kd}\right);\ m = 0, 1, 2, \ldots$$

and the array factor has at least one maximum along $\theta = 0$. (6 marks)

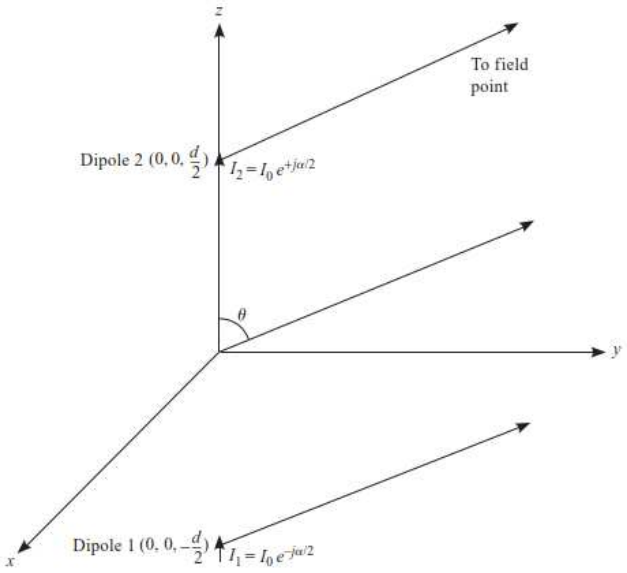

Figure Q2 (b)

c) Find and plot the array factor for three identical antenna arrays, which individually consists of two isotropic elements. Elements of array are separated by 10 cm and each element is excited in phase and fed by a signal of 1.5 GHz. (11 marks)

QUESTION THREE (20 MARKS)

a) Briefly explain the following types of waves highlighting their range of useful frequencies:

i. Ground waves

ii. Space waves

iii. Sky waves. (6 marks)

b) With the aid of suitable diagrams illustrate how the following diversity techniques are used to mitigate the effects of fading:

i. Space diversity

ii. Frequency diversity. (9 marks)

c) A communication system is to be established at a frequency of 60 MHz with a transmitter power of 1 kW watts. The field strength of the directive antenna is 3 times that of a half-wave antenna. $h_t = 50$ m, $h_r = 5$ m. Field strength of 80μ V/m is required to give satisfactory reception. Determine the range of the system. (5 marks)

QUESTION FOUR (20 MARKS)

a) State THREE applications of horn antenna. (3 marks)

b) With the aid of a suitable diagram briefly describe the principle of operation of a horn antenna. (8 marks)

c) Design a log-periodic dipole array having a directivity of 8.5 dB over a frequency range of 10 MHz to 30 MHz. Assume scale factor of $\tau = 0.895$ and spacing factor of $\sigma = 0.166$. (9 marks)

QUESTION FIVE (20 MARKS)

a) Define the term Line-of-Sight (LOS) and highlight the factors influencing it. (5 marks)

b) Illustrate the following phenomena using suitable sketches:

i. Duct propagation

ii. Troposcatter. (8 marks)

c) Determine the frequency of wave propagation through an ionosphere layer with refractive index of 0.6 and electron density 3.25×10^5 electrons/cc. Also, determine the corresponding change in frequency, if the refractive index increases by 35%. (7 marks)