TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING

UNIVERSITY EXAMINATION 2017/2018

DEGREE OF BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONIC ENGINEERING)

EEE 2516: ANTENNA & PROPAGATION

SPECIAL/SUPPLEMENTARY EXAMINATION

SERIES: SEPTEMBER 2018

TIME: 2 HOURS

DATE: Sep 2018

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of FIVE questions. Attempt **Question ONE (Compulsory)** and any other **TWO Questions**

Do not write on the question paper.

$\mu_0 = 4\pi \times 10^{-7}$ H/m $\qquad$ $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m

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Question ONE (Compulsory)

a. An antenna operating at 150 MHz has a physical aperture area of $100\ m^2$, a gain of $23\ dB$, and a directivity of $23.5\ dB$. Compute:

   i. The effective aperture

   ii. The maximum effective aperture

   iii. The aperture efficiency (6 marks)

b. Show that the array factor of an N-element array of z-directed $\lambda/2$ dipoles kept along the z-axis at z_1', z_2', z_3', $\cdots$, z_N' and carrying currents I_1, I_1, I_1, $\cdots$, I_N, respectively is given by

$$AF = \sum_{n=1}^{N} I_n\, e^{jkz_n' cos\theta}$$

(10 marks)

c. A line-of-sight $2.4\ GHz$ microwave link is to be established on the surface of the earth (mean radius $6370\ km$). The straight line distance between the two antennas is $50\ km$ and the height of the transmit antenna is $60\ m$. Calculate the minimum height of the receive antenna assuming that the propagation is taking place in the absence of atmosphere. (4 marks)

d.

i. Derive an expression for the half-power beamwidth of the x-y plane pattern of a $\lambda/2$ dipole placed in front of a flat reflector a distance d from the reflector.

ii. Determine the half-power beamwidth if $d = \lambda/4$. (10 marks)

Question TWO

a. Show that the total radiated power of a Hertzian dipole of length dl excited by a current I_0 is given by

$$P_{rad} = \eta \frac{\pi}{3}\left(I_0 \frac{dl}{\lambda}\right)^2$$

If the dipole is oriented along the z-direction, show that the directivity is given by $D(\theta, \varphi) = 1.5 sin^2\theta$

(14 marks)

b. A short dipole of length 0.1λ is kept symmetrically about the origin, oriented along the z-direction and radiating $1\ kW$ power into free space. Calculate the power density at $r = 1\ km$ along $\theta = 45$ and $\varphi = 90$. (6 marks)

Question THREE

a. Show that the input resistance of a $\lambda/2$ folded dipole is four times that of single half-wave dipole.

(6 marks)

b. Calculate the dimensions of a Yagi–Uda array that has a directivity of $12\ dB$ at $145\ MHz$.

(5 marks)

c. Design and plot the array factor for an ordinary endfire, five-element, uniformly excited array with spacing d = 0.35λ. Find the inter-element phase shift α. (9 marks)

Question FOUR

a. Assume the array of current elements of currents I_1, I_2, I_3 , shown in the following Figure Q4(a). All elements have equal lengths Δl. The first and third antenna are at $z = \pm\lambda/2$.

i. Find the expression of the radiated far-field from the array
ii. Sketch the pattern of the antenna on the yz plane if $I_1 = 1,\ I_2 = j,\ \text{and}\ I_3 = 1$.
iii. If $I_1 = 1,\ I_2 = j,\ \text{and}\ I_3 = 1$, determine the polarization of the far-field. (12 marks)

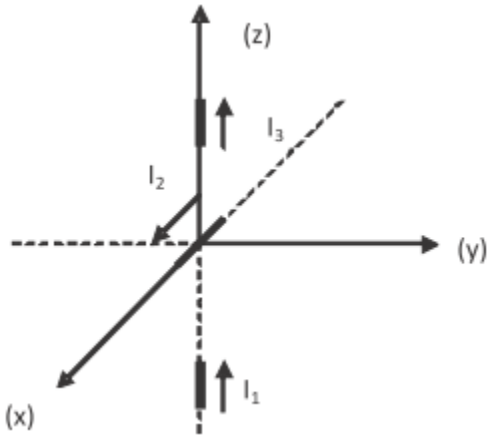

Figure Q4(a)

b. A $7.5\ GHz$ microwave link with a path length of $25\ km$ has a maximum acceptable path loss of $169\ dB$. The transmitter antenna is mounted at a height of $20\ m$ above the ground level, while the height of the receiver antenna is to be determined. The ground is level apart from a hill of height $70\ m$, located $10\ km$ away from the transmitter antenna. Calculate:

i. The total path loss assuming the receiver antenna is mounted at a height of $20\ m$ above ground level.
ii. The height of the receiver antenna for the path loss to be just equal to the maximum acceptable value. (8 marks)

Question FIVE

a. An antenna has a normalized radiation intensity given by

$$F(\theta,\varphi) = \begin{cases} \sin^2\theta\cos^2\varphi, & 0 \le \theta \le \pi, -\frac{\pi}{2} \le \varphi \le \frac{\pi}{2} \\ 0 & elsewhere \end{cases}$$

Determine the following:

i. The direction of maximum radiation.
ii. Directivity.
iii. Beam solid angle.
iv. Half-power beam width in the xz −plane. (12 marks)

b. A free-space LOS microwave link operating at $12.5\ \text{GHz}$ consists of a transmit and a receive antenna each having a gain of $20\ \text{dB}$. The distance between the two antennas is $35\ \text{km}$ and the power radiated by the transmit antenna is $10\ \text{W}$. Calculate:

i. The path loss of the link

ii. The received power. (8 marks)