University of Eswatini
Faculty of Science and Engineering
Department of Electrical and Electronic Engineering
Main Examination 2020

Title of Paper : **Antenna and Wave Propagation**

Course Number : **EEE544 /EE54/**

Time Allowed : **3 hrs**

Instructions :

1. **Answer any four (4) questions**
2. **Each question carries 25 marks**
3. **Some useful information is attached at the end of the question paper**
4. **Make sure there are 4 pages including the cover page**

THIS PAPER SHOULD NOT BE OPENED UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR

QUESTION 1

(a) (8 pts.) Define the following terms:

(i) Antenna efficiency

(ii) Beam efficiency

(iii) Antenna aperture

(iv) Radiation intensity

(b) (4 pts.) What is the difference between

(i) Directive gain and power gain

(ii) HPBW and FNBW

(c) (3 pts.) An antenna has 13dB gain and its radiation efficiency is 95%. What is the directivity in dB?

(d) (10 pts.) A transmitting antenna with an effective height of 60m has a current at the base 50A (rms) at the frequency of 300kHz. Determine

(i) The field strength at a distance of 10km

(ii) The power radiated

QUESTION 2

(a) (10 pts.) For a small dipole antenna, the radiated power is given as:

$$P_{avg} = \frac{P_0 sin^2\theta}{r^2}\hat{a}_r$$

Calculate the directivity and effective aperture of the antenna for $\lambda = 1.3$.

(b) (10 pts.) In a microwave communication link, two identical antennas operating at 10GHz are used with power gain of 40dB. If the transmitter power is 1W, find the free space loss factor and the received power, if the range of the link is 20km. (here $G_t = G_r$).

(c) (5 pts.) If the electric field at 5km distance from an aerial is 10mV/meter, what is the value at a point 10km away in the same direction?

QUESTION 3

(a) (15 pts,) What is an antenna array? Explain the behaviour of broad-side and end fire arrays. Two identical point sources separated by a distance d, each source having a field pattern given by $E_0 = E_1 \sin\theta$. If $d = \lambda/2$ and the phase angle $\alpha = 0$, drive an expression for the total field pattern. Plot the pattern.

(b) (10 pts.) Find the FNBW and HPBW for broadside linear array and an end fire linear array consisting of 20 Hertizian dipole with $\lambda/2$ separation and $\lambda/4$ separation, respectively.

QUESTION 4

(a) (15 pts.) What is the operating principle of log-periodic antenna? The upper VHF tv channels broadcast from 174 to 216 MHz. Find the dimensions of a log periodic antenna with $r = 0.95$ and $d = 0.75\lambda$.

(b) (10 pts.) Calculate the BWFN and HPBW of a 2.5m paraboloid reflector used at 6GHz. What will be its gain in dB ?

QUESTION 5

(a) (8 pts.) Write short notes on the D, E, F1, and F2 layers and explain the diurnal and seasonal cycle variations.

(b) (6 pts.) Explain the meaning and characteristics of

(i) Ground wave propagation

(ii) Space wave propagation

(c) (11 pts.) A transmitter radiates 20 watts of power at a wave length of 4cm. Calculate the power received by an antenna at a distance of 100 km if the gains of the transmitting and receiving antennas are equal and have a value of 25dB.

Some useful formulas and constants:

$$c = 3 \times \frac{10^8 m}{s}$$

1 radian=57.3 degree

$$\eta = \frac{E}{H} = 120\pi \; ohms$$

For current element:

$$P = 80\pi^2 I_{rms}^2 (\frac{dl}{\lambda})^2$$

$$E_{rms} = \frac{120\pi I_{rms} l_e}{\lambda r}$$

Total radiated power in radial direction

$$P_{rad} = \int_0^{2\pi} \int_0^{\pi} \Phi \sin(\theta) d\,\theta d\phi,$$

Φ is the radiation intensity

$$D = \frac{4\pi\, \Phi_{max}}{P_{rad}}$$

For two antennas one transmitting and the other receiving,

$$P_r = G_t G_r (\frac{\lambda}{4\pi r})^2 P_t$$

$$L_s(dB) = 32.45 + 20log_{10}r + 20log_{10}f$$

For arrays of two point sources

$$E = 2E_0 \cos(\psi/2), \text{ where } \psi = \frac{2\pi}{\lambda} d \cdot cos(\theta)$$

For broadside array $BWFN = \frac{2\lambda}{nd}$ and for end-fire array $BWFN = 2\sqrt{\frac{2\lambda}{nd}}$