Assignment 1: Antenna Fundamentals

Problem 1.1

An aperture antenna is radiating in free space. The dimensions of the aperture are $a = 7.112$ mm and $b = 3.556$ mm.

a) What are the three field regions of this antenna?

b) Determine the boundaries of these regions, as a function of wavelength.

Problem 1.2

Find the far-field distance for an antenna with maximum dimension of 1 m and operating frequency of 900 MHz.

Problem 1.3

If a transmitter produces 50 W of power, express the transmit power in units of

a) dBm,

b) dBW.

Problem 1.4

The maximum of the radiation pattern of a horn antenna is +20 dB, while maximum of its first side-lobe is –15 dB. What is the difference between the two maxima

a) in dB,

b) as a ratio of the field intensities.

Problem 1.5

A circular disc is lying in the plane $y_0 = 0.6$, whereas its center lies on the y-axis. The radius of the disc is $r_d = 0.3$.

a) Calculate the solid angle covered by this disc seen from the origin of the coordinate system.

b) Calculate the solid angle covered by this disc lying in the plane $y_0 = 30$.

Problem 1.6

A hypothetical isotropic antenna is radiating in free space. At a distance of 100 m from the antenna, the total electric field (E_θ) is measured to be 5 V/m.

a) Find the power density W_{rad}.

b) Determine the power radiated P_{rad}.

Problem 1.7

The power radiated by a lossless antenna is 10 W. The directional characteristics of the antenna are represented by the radiation intensity of

$$U = B_0 \cos^3 \theta \text{ [W/sr]} \qquad \text{for } 0 \leq \theta \leq \pi/2 \text{ and } 0 \leq \phi \leq 2\pi$$

a) Find the maximum power density [$\mathrm{W/m^2}$] at a distance of 1000 m (assume far field distance). Specify the angle where this occurs.

b) Find the directivity of the antenna (dimensionless and in dB).

c) Calculate the half-power beamwidth (HPBW).

d) Find the first-null beamwidth (FNBW).

Problem 1.8

The normalized radiation intensities of three antennas are given by

- $U = \sin\theta \cdot \sin\phi$
- $U = \sin\theta \cdot \sin^2\phi$
- $U = \sin^2\theta \cdot \sin\phi$

The intensity exists only in $0^\circ \le \theta \le 180^\circ, \quad 0^\circ \le \phi \le 180^\circ$ region, and is zero elsewhere.

a) Find the maximum directivities (dimensionless and in dB).

b) Find the azimuthal and elevation plane half-power beamwidth (in degrees).

c) Find the approximate directivities by using Tai & Pereira's formula.

Problem 1.9

The normalized far-zone field pattern of an antenna is given by

$$E = \begin{cases} \left(\sin\theta \cdot \cos^2\phi\right)^{1/2} & 0 \le \theta \le \pi, \quad 0 \le \phi \le \frac{\pi}{2} \quad \text{and} \quad \frac{3\pi}{2} \le \phi \le 2\pi \\ 0 & \text{elsewhere} \end{cases}$$

The E-field vector points in θ -direction.

a) Find the directivity using the exact expression.

b) Find HPBW of the E- and H-planes of the antenna.