Antenna Parameters: A practical Approach

Directivity

1. – The electric field pattern of an antenna is independent of ϕ, and varies across θ as follows:

$$E = \begin{cases} 1 & 0^\circ \leq \theta < 45^\circ \\ 0 & 45^\circ \leq \theta < 90^\circ \\ \frac{1}{2} & 90^\circ \leq \theta < 180^\circ \end{cases}$$

Determine the directivity of the antenna. Assume it is in free-space.

Hint: $U = \frac{r^2|E|^2}{\eta}$, $D = \frac{4\pi U_{max}}{P_{rad}}$

Polarization

A ground-based helical antenna is placed at the origin of a coordinate system and it is used as a receiving antenna. The normalized far-zone electric-field by the helical antenna is given by

$$\boldsymbol{E}_a = \left(j\hat{\boldsymbol{a}}_{\boldsymbol{\theta}} + 2\hat{\boldsymbol{a}}_{\boldsymbol{\phi}}\right) f_o(\theta_o, \phi_o) \frac{e^{-jkr}}{r}$$

A flying aircraft is transmitting towards the antenna (θ_o, ϕ_o), which far-field electric field is given by

$$\boldsymbol{E}_w = \left(2\hat{\boldsymbol{a}}_{\boldsymbol{\theta}} + j\hat{\boldsymbol{a}}_{\boldsymbol{\phi}}\right) f_1(\theta_1, \phi_1) \frac{e^{+jkr}}{r}$$

Determine:

1. The polarization of the helical antenna, and sense of rotation (if any)
2. The polarization of the transmitting aircraft, and sense of rotation (if any)
3. Polarization loss

   Hint: For the polarization loss, use $\mathrm{PLF} = |\hat{\boldsymbol{\rho}}_{\mathrm{a}} \cdot \hat{\boldsymbol{\rho}}_w|^2$

Antenna Impedance, Input Impedance, and Power

A half-wave dipole antenna is connected to a source of 150 MHz and 100 V, and has an internal resistance of $50\ \Omega$. The antenna has an impedance given by $Z_A = 73 + j42.5\ \Omega$, with an ohmic loss given by $R_L = 1.625\ \Omega$.

Find:

1. The current going into the antenna
2. The power radiated by the antenna
3. The power dissipated (lost) by the antenna
4. The antenna efficiency

Antenna Communications

A base station has a dipole antenna installed. It has a maximum directivity of $2.286\ \text{dB}$ and has a power source capable of transmitting $10\ \text{W}$. The frequency of operation is $1{,}900\ \text{MHz}$. The station communicates with an unmanned terrestrial vehicle that drives about $1\ \text{km}$ away, which has a dipole antenna with maximum gain of $5.286\ \text{dB}$. Calculate the maximum power transmitted from the station to the vehicle, assuming the antennas polarization matched, there are no matching/reflection losses, maximum efficiencies, and the antennas are pointed along the direction of maximum directivity.