EXERCISE 2: DIPOLE, MONOPOLE & LOOP ANTENNAS

Problem (1)

Consider a center-fed dipole antenna of length $3\lambda/2$. Determine the zeros and maxima of the radiation pattern as well as the maximum of the directivity function, given that R_{rad} = 105 Ω.

Problem (2)

1. Derive an expression for the total field of a current element. Comment on the variation of the different field components. Is the radiated wave TEM?
2. Derive an expression for the radiated fields of a short dipole. Obtain an expression for the radiation resistance and directivity.
3. Derive an expression for the radiated fields of a small loop antenna. Obtain an expression for the radiation resistance and directivity.

Problem (3)

A thin center-fed dipole antenna of length L = 50 cm is fed with input current 100 mA at 30 MHz. The antenna is situated on the Y-axis in free space.

1. Calculate the power radiated by the antenna
2. Obtain expressions for the radiated fields.
3. Specify the results of (b) for the principal planes and draw the radiation field patterns.
4. Determine the directivity function.
5. Calculate the maximum radiation power density 1-km away from the antenna.

Problem (4)

A thin center-fed dipole 0.1-m long, oriented in the direction (θ = 45°, ϕ = 90°) and operated at 300 MHz, has 0.1 A feed current.

1. Obtain an expression for the directivity function $D(\theta,\phi)$ and specify you result to the principal planes.
2. Determine the total radiated power.
3. Determine the radiated power density 100 m away in directions (45°,–90°), (45°,90°), (90°,90°), (90°,0°). Show graphically without any formulation the polarization of radiated fields.

Problem (5)

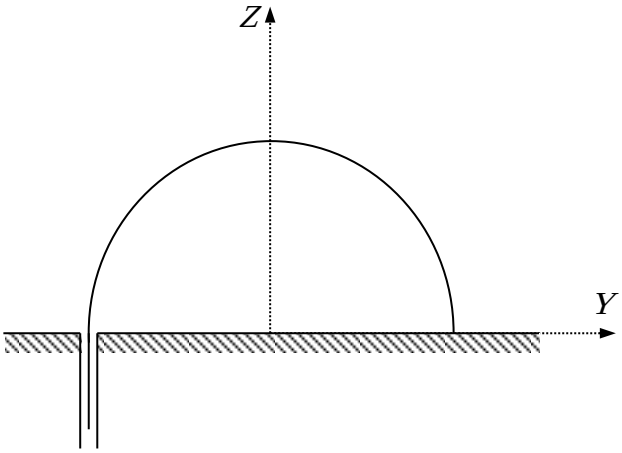
1. Show that the unattenuated radiation field at the surface of the earth of a quarter-wave monopole is given by:

$$E_{rms} \approx 9.9\frac{\sqrt{W}}{r}\ \text{mV/m}$$

   where r is the distance in km, W is the radiated power in watts.
2. Obtain the corresponding expression for a short monopole.

Problem (6)

Consider the small half-loop antenna above a large conducting screen, with coaxial feed as shown in the figure. Give expressions for the radiated fields and draw the directional patterns in principal planes showing the polarization of radiated fields.

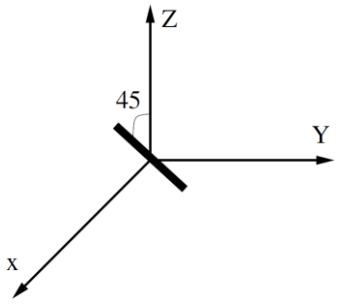


Problem (7)

1. Obtain expressions for the electromagnetic fields radiated by a small circular loop antenna. Show that the radiation resistance equals $20\pi^2(\pi D/\lambda)^4$ Ω, where *D* is the loop diameter and λ is the operating wavelength.
2. A loop antenna of diameter 10 cm is operated at 100 MHz with a 0.1 A feed current. The axis of the loop is oriented in the direction (ϑ = 45°, φ = 90°).
   a. Draw without any formulation the directional patterns in the *YZ*, *XZ* and *XY* planes.
   b. Calculate the radiation intensity and show graphically the electric field polarization in the directions (45°,–90°), (45°,90°) and (90°,90°).

Problem (8)

An infinitesimal dipole element of length $\Delta\ell$ is placed in the X-Z plane and oriented with 45° with Z-axis as shown in the figure. The current on the dipole is assumed, I_0.



1. Derive the radiation electric field of that dipole.
2. Find the polarization of the radiation electric field at points on the x, y and z axes.

Useful Relations

- $\begin{pmatrix} A_r \\ A_\theta \\ A_\varphi \end{pmatrix} = \begin{pmatrix} \cos\varphi\sin\theta & \sin\varphi\sin\theta & \cos\theta \\ \cos\varphi\cos\theta & \sin\varphi\cos\theta & -\sin\theta \\ -\sin\varphi & \cos\varphi & 0 \end{pmatrix} \begin{pmatrix} A_x \\ A_y \\ A_z \end{pmatrix}$
- $\cos\psi = \cos\theta\cos\theta' + \sin\theta\sin\theta'\cos(\varphi - \varphi')$