EE2025 Engineering Electromagnetics: July-Nov 2019

Tutorial 7: Antennas and Antenna Arrays

1. (a) Find the electric and magnetic fields generated by an Hertz dipole antenna?
   (b) Show that the power radiated in a far field and near field regions from a Hertzian dipole is independent of the distance of a test object from the antenna.

2. A $1m$ long dipole is excited by a $5MHz$ current with an amplitude of $5A$. At a distance of $2km$, what is the power density radiated by the antenna along $\theta = 90^\circ$ (broadside direction)?

3. The power radiated by a lossless antenna is 10 watts. The directional characteristics of the antenna is represented by the radiation intensity of $U(\theta, \phi) = B_0 \cos^3\theta$ (W/unit solid angle) $0 \leq \theta \leq \pi/2$ $0 \leq \phi \leq 2\pi$ Find
   a) Maximum power density (in watts per square meter) at a distance of 1000m (assume far field). Specify the angle where it occurs.
   b) Directivity of the antenna (dimensionless and in dB)

4. Calculate the directivity, total power radiated and radiation resistance of an half-wave dipole (length = $\lambda/2$) antenna with far fields given below:

$$E_\theta \simeq \frac{j\eta I_0 e^{-jkr}}{2\pi r}\left[\frac{\cos(\frac{\pi}{2}\cos\theta)}{\sin\theta}\right]$$

$$H_\phi \simeq \frac{jI_0 e^{-jkr}}{2\pi r}\left[\frac{\cos(\frac{\pi}{2}\cos\theta)}{\sin\theta}\right]$$

   Hint: $\int_0^\pi \frac{\cos^2(\frac{\pi}{2}\cos\theta)}{\sin\theta} d\theta = 1.21883$

5. An antenna has been designed as a half wavelength dipole for use with a TV transmitter at 600 MHz (UHF channel 35) and the transmitter supplies 50 kW to the antenna. The antenna is 6 mm thick and made of aluminium with conductivity $\sigma = 3 \times 10^7$ S/m. Consider the radiation resistance of dipole (R_{rad}) is $73.08\,\Omega$ and the current is uniform. Calculate:
   (a) The radiated power at 600 MHz
   (b) The efficiency of the antenna ($eff = \frac{P_{rad}}{P_{in}} = \frac{R_{rad}}{R_{rad}+R_{in}}$)

6. Four isotropic sources are placed along the z-axis as shown in Fig.1. Assuming that excitations of elements (current fed to the elements) 1 and 2 are +1 and the excitations of elements 3 and 4 are -1 (180^0 out of phase with 1 and 2). Find
   (a) The array factor in simplified form
   (b) All the nulls when $d = \frac{\lambda}{2}$.

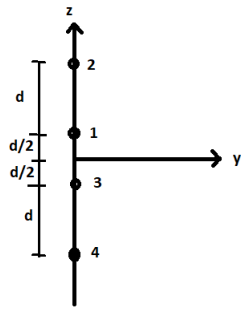

Figure 1: isotropic sources

7. Consider two isotropic antennas kept in a plane separated by a distance of two wavelengths. If both the antennas are fed with currents of equal phase and magnitude. Calculate the number of lobes in the radiation pattern.

8. Obtain an expression for the array factor of a two-element array of isotropic antennas with equal excitation and a separation $d = n\lambda/2$ where $n \in \mathbb{N}$. The array is along the x-axis. How many beams are there between $\phi = 0$ and $\phi = 180$ in the radiation pattern? Do they have the same width and peak value?

9. For a uniform linear array of N isotropic antennas, determine the directivity of the antennas when the spacing between the elements is 'd' and further find directivity when d is a) $\lambda/4$
   b) $\lambda/2$

10. In a linear array of antennas with the same spacing between each element, four isotropic radiating elements are spaced $\frac{\lambda}{4}$ apart. What should the relative phase shift between the elements required for forming the main beam at 60 degrees with the axis of the array?

11. 1. **Practice Exercise :** Open your mobile phones ,go to Settings− >About Phone− >Status (or Network) On this screen, view Signal Strength (or Network Type and Strength). Check your signals strength will be in dBm which is a unit of level used to indicate that a power ratio is expressed in decibels (dB) with reference to one milliwatt (mW).Convert the signal strength from dBm to mW.
    2. Suppose a person with a receiver is 5 km away from the transmitter. What is the distance that this person must move further to detect a 3 dB decrease in signal strength?