EEE 452/552 Due 02/04/2008

Homework #7

(1) Radiation intensities of two different lossless antennas are given by

$$U_1(\theta,\phi) = \begin{cases} B_1 \sin^2\theta \sin^3\phi & 0 \le \theta \le \pi \;,\; 0 \le \phi \le \pi \\ 0 & \text{else} \end{cases}$$

$$U_2(\theta,\phi) = \begin{cases} B_2 \sin^3\theta \sin^4\phi & 0 \le \theta \le \pi \;,\; 0 \le \phi \le \pi \\ 0 & \text{else} \end{cases}$$

(a) Using MATLAB plot the radiation intensities at polar coordinates on x-y and y-z planes for both of the antennas. Normalize the plots as max. value to be 1.

(b) Use MATLAB. Sample the radiation intensities with $\pi/20$-radian steps in both θ and ϕ. With total 21x21 samples, determine the directivities (dimensionless) of both antennas numerically.

(c) Find the directivities analytically and compare your results with the ones found in (b).

(d) Find B_1 and B_2 if the total radiated power is required to be 2 Watts for both of the antennas.

(e) Find the azimuthal and elevation plane half-power beam widths in degrees.

(2) Two lossless antennas have radiation intensities given by

$$U_1 = \begin{cases} 2\sin\theta \sin\phi \left| \sin(\phi - \pi/5) \sin(\phi + \pi/5) \right| & 0 \le \theta \le \pi \;,\; 0 \le \phi \le \pi \\ 0 & \text{otherwise} \end{cases}$$

$$U_2 = \begin{cases} 2\sin\theta \sin\phi \left| \sin(\phi - \pi/7) \sin(\phi + \pi/7) \right| & 0 \le \theta \le \pi \;,\; 0 \le \phi \le \pi \\ 0 & \text{otherwise} \end{cases}$$

(a) Using MATLAB, plot the radiation intensity w.r. to ϕ on the x-y plane.

(b) Using MATLAB find the azimuthal plane half-power beam width in degrees.

(c) Find the sidelobe level (SLL) in dB (use MATLAB).

(d) Find the maximum radiation density at a distance 1000m for each antenna (Assume far-field).

(3) In Homework #6, question (4) you found the far-field expression of a very thin dipole whose current distribution is approximated as

$$I(x'=0, y'=0, z') = \begin{cases} \hat{a}_z I_o \sin\left[k\left(\frac{l}{2} - z'\right)\right] ; & 0 \le z' \le l/2 \\ \hat{a}_z I_o \sin\left[k\left(\frac{l}{2} + z'\right)\right] ; & -l/2 \le z' \le 0 \end{cases}$$

You can show that (not necessary read pp. 170–173 of your book)

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

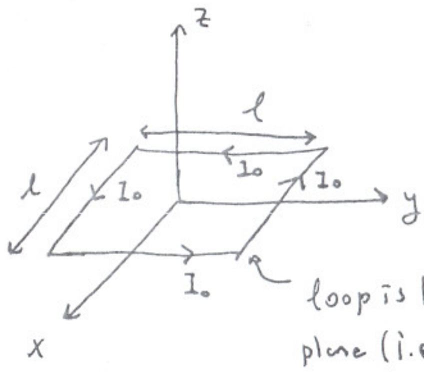
$$H_\phi \simeq \frac{E_\theta}{\eta}.$$

Find the radiation intensity $U(\theta, \phi)$ of this antenna, and for the elevation plane (for example z-y or z-x planes) plot the normalized power patterns for $l = \lambda/2$, $l = \lambda$, $l = 1.25\lambda$ on the top of each other using MATLAB (I want a MATLAB figure). Check your results (i.e., your plots) with the ones given on pages 174 and 175 (see Fig. 4-6 and Fig. 4-7 (b)).

(4) Consider an electrically small square-loop antenna as shown in the figure. The current has a constant amplitude I_o and a zero phase around the loop. Each side of the square loop is very short ($l \ll \lambda$), uniform electric current segment that can be modeled as an ideal (infinitesimally Hertzian) dipole. For this geometry determine the far-zone $\bar{E}$ and $\bar{H}$ fields.

Hints: $kl = \frac{2\pi}{\lambda} l \ll 1$

for $|x| \ll 1$ $\sin(x) \approx x$



loop is located at x-y plane (i.e., at z=0 plane)