THE UNIVERSITY OF TEXAS AT DALLAS

Electromagnetic Engineering I

EE 4301

Spring 2008
Assignment 13

Due Date and Time:

At the beginning of class, April 21, 2008

Reading:

N. N. Rao, *Elements of Engineering Electromagnetics*, **Sixth Edition**, Chapter 10

Problems:

Please write your answers to the following problems on engineering paper. No credit will be given for work handed in on other types of paper.

1. An antenna radiates a total power $W = 8\,\mathrm{W}$.
   (a) What is the radiation intensity if the total power is radiated uniformly in all directions? [Recall that the radiation intensity is defined as the power radiated per unit solid angle.]
   (b) What is the radiation intensity $K(\theta)$ as a function of the angle θ (between the axis of the antenna and the line of sight) given that the directive gain is that of a Hertzian dipole? [Hint: You really need to know only the definition of directive gain,
   $$g_d(\theta) = K(\theta)/[W/(4\pi)],$$
   and the result for the directive gain of a Hertzian dipole,
   $$g_d(\theta) = 1.5\sin^2(\theta).$$

2. An antenna radiates a total power $W = 12\,\mathrm{W}$.
   (a) What is the radiation intensity of an antenna that radiates a total power of 12 W isotropically?
   (b) If the radiation resistance of the antenna is 4Ω, what is the peak value of the current in the antenna? [Hint: Don't confuse RMS values with peak values!]
   (c) Find the radiation intensity of an antenna that radiates a total power of 12 W if the directive gain is
   $$g_d(\theta) = 1.64\left\{\frac{\cos\left[\left(\frac{\pi}{2}\right)\cos\theta\right]}{\sin\theta}\right\}^2.$$

(d) What is the directivity of an antenna whose directive gain is given by the preceding equation? [Hint: The maximum value of the expression in braces ($\{\}$) occurs for $\theta = \pi/2$.]

3. The antenna at an Earth node of a satellite communication link has a directivity of 55 dB at a frequency of 12.45 GHz. [Hint: This means that $D = 10^{5.5}$. If you don't understand the hint, please review decibels. Yes, decibels will be on the test.] The antenna is aimed at a geosynchronous satellite that is at a distance 36,500 km. The antenna on the satellite has a directivity of 35 dB in transmitting a signal towards Earth. The minimum usable signal power at the Earth node's receiver is 8 pW. Find the minimum useful satellite transmitter power, assuming that there are no losses in the system. Express your answer in dBW, meaning dB above a power of 1 W. [Example: $3 \text{ dBW} = 10^{0.3} \times 1 \text{ W} = 2 \text{ W}$.

4. Find the maximum range, R, of a communication system for which $D_T = 33$ dB, $D_R = 30$ dB, $f = 12$ GHz, the transmitter power is 20 dBW, and the minimum usable receiver power is -110 dBW. Assume that there are no losses in the system.

5. A dipole antenna of total length $h = 3$ mm is center-fed by a current that is sinusoidal in time at a frequency $f = 10$ GHz. The antenna's center is located at the origin, and the antenna points along the z axis. Assuming that the phasor amplitude of the current distribution in the antenna can be approximated by the triangular function

$$\tilde{I}(z) = I_0 \left(1 - \frac{2|z|}{h}\right),$$

where $I_0 = 3$ A,

(a) Find the electric and magnetic fields in the radiation zone. [Hint: Is $h \ll \lambda$?]

(b) Find the Poynting vector.

(c) Find the total power radiated.

(d) Find the radiation resistance.

(e) Find the directive gain.

(f) Find the directivity.

6. N. N. Rao, *Elements of Engineering Electromagnetics*, **Sixth Edition**, Exercise P10.7.

7. N. N. Rao, *Elements of Engineering Electromagnetics*, **Sixth Edition**, Exercise P10.8.

8. N. N. Rao, *Elements of Engineering Electromagnetics*, **Sixth Edition**, Exercise P10.9.

9. N. N. Rao, *Elements of Engineering Electromagnetics*, **Sixth Edition**, Exercise P10.12.

10. N. N. Rao, *Elements of Engineering Electromagnetics*, **Sixth Edition**, Exercise P10.13.

11. N. N. Rao, *Elements of Engineering Electromagnetics*, **Sixth Edition**, Exercise P10.17.