UNIVERSITY OF UTAH
ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT

ECE 5324/6324 HOMEWORK PROBLEMS 1-7 Spring 2013

1. Calculate and compare the power density and electric field strength for $\theta = 90°$ for a distance of 20 km from dipole antennas radiating 100 W of power at 1.30 MHz. Consider antennas of the following lengths:

   a. $L = 0.03\ \lambda$
   b. $L = 0.15\ \lambda$
   c. $L = 0.5\ \lambda$
   d. $L = 0.9\ \lambda$
   e. $L = 1.3\ \lambda$

   How does the electric field strength vary as the antenna length is increased from 0.03λ to $1.3\ \lambda$ i.e. by a factor of nearly 44:1?

   Hint: Read and follow a procedure similar to Example 1 on p. 9 of Class and make a table of the results with R_a, I_a, I_m, $F(\theta)|_{\theta=90°}$, E, and S.

2. Calculate also the directivity D and gain for each of the above antennas for the direction/s $\theta = 90^{\circ}$. Express the results for the calculated gains in dB.

   To calculate ohmic resistance, take aluminum as the material for the antenna. From Appendix B on p. 783 of the Text, take 2a = 2.588 mm (No. 10AWG wire).

   Note: A feature of the above problems 1 and 2 is that for fairly large variations of antenna lengths, the field strengths at a receiving site are not that different. Ohmic losses, which are typically relatively negligible for longer antennas can, however, become significant for the shortest antenna of length $L = 0.03\ \lambda$ because of fairly low driving point resistance.

3. Calculate the electric field strength for $\theta = 60°$ for the antennas in Problem 1. Express your results also in terms of dB relative to E_{max} i.e.

$$20 \log_{10}\left(|E(\theta)|_{\theta=60°}\right)/|E_{max}|_{\theta=90°}$$

4. Plot the radiation patterns in the E-plane (i.e. as a function of θ) for the antennas of Problem 1a, c, and e. Use a polar plot and both the log and the linear scales in plotting the radiation patterns. Determine the half power beamwidth (HP or HPBW) of the antenna for each of the cases.

5. A certain antenna installation using a transmitting frequency of 1300 kHz uses an insulated vertical tower of height 200 feet. For a 25 kW transmitter power, calculate the electric field strength at a location A at a distance of 25 km.
   (Note that 1foot of distance = 0.3048 meter)

   Calculate also the field strength at a location B that is 5 km vertically above location A (Note that $\theta \neq 90°$ for location B).

6. Calculate the driving point reactances for each of the dipole antennas of Problem 1. Assume a diameter of $0.002\ \lambda$ and length $L' = 1.06L$ for each case.

7. Show that the ohmic resistance of a half-wave dipole from Eq. (9) on p. 13 of Class Notes is given by

$$R_{ohmic} = \frac{R_s L}{4\pi a} = \frac{R_s \lambda}{8\pi a}$$

which is the same as that given in Problem 3.2-4, p. 97 of the Text.
Hint: $\beta L = \pi$ for a half-wave dipole.

Note that for a center-fed dipole of **arbitrary length L**, the general expression for the ohmic resistance is given in Eq. (9) on p. 13 of Class Notes.