ECE 123 **Assignment 6** **Spring 2009**

This problem set is due Wednesday May 27

The objective of this exercise is to study a simple dipole which is half a wavelength long at the design center frequency of 300 Mhz. It is to be oriented in the z direction and the wire radius is 1mm.

1. Use SuperNEC to simulate the dipole over a frequency range from 10 MHz to 1000 MHz. The “Frequency Scaling” parameter should be set to the maximum frequency you want to simulate divided by the design frequency. That will be 1000/300 = 3.3. This will help SuperNEC choose the optimal number of segments in the structure. Then you need to set the frequency range. Choose Edit/Simulation_Settings and change the frequency range to [10:2:1000].

(a) Plot the input impedance on a Smith Chart. Choose “Parameter vs Freq”, then “Excitation”. Change the reference impedance to 75Ω, which would be appropriate if you were driving the dipole from a transmission line of $Z_0 = 75\Omega$ (this is the impedance of the foam filled coax used for cable TV). The dipole should be quite well matched near its first resonance. Put markers on the first three resonances and the locations where the VSWR=2. Make a hard copy of the Smith Chart. Switch the “format” to “VSWR” and set the maximum on the y-axis to VSWR=10. Make a hard copy. What is the bandwidth of the first resonance at VSWR=2? Switch the format to “return loss” and make a hard copy. What is the bandwidth of the first resonance at return loss = -10dB?

(b) Calculate the radiation resistance vs length using the sinusoidal current approximation. Compare this with the simulated resistance. You can download the simulation into matlab using the “workspace” button on the SuperNEC output interface. By default it will create a data structure called towork. The frequency is “towork.freq” and the resistance is real(towork.impedance), so it is easy to plot the simulation over your calculated radiation resistance. Make a hard copy.

2. Resimulate adding a 3-D Radiation Pattern calculation at 4 deg intervals to the “Simulation_Settings”. This will take longer, but you don’t need to sample as densely in frequency. An increment of 10 MHz will be sufficient. Plot the radiation pattern selecting all frequencies. This will provide a 3-D display from which you can select 2-D cuts. You can change the frequency of the pattern plot in the plot window. If you select “overlay” you can get all the 2-D plots on one graph.

(a) Make 2-D plots (on the same graph) at 10 MHz, and the three resonances. Put markers on the peak gain. Make hard copies in polar and rectangular form. Explain the behavior of the pattern at the third resonance qualitatively in terms of the current distribution on the antenna.

(b) Make a separate rectangular plot of the gain at 10 MHz. Overplot the theoretical gain of a short dipole. Here you will need the vector “towork.theta”. The gain is a 4-D array “towork.gain”. The dimensions are: phi, theta, polarization, frequency. You want any phi, all theta, the first polarization, and the first frequency, i.e. gain(theta) = towork.gain(1,theta,1,1). How well do they compare?

3. The bandwidth of an antenna is often defined as the frequency range over which the VSWR < LIMIT or the reflected power < some limit. The VSWR limit is often ≈ 2. Usually one defines the fractional bandwidth as $BW = (f_2 - f_1)/\sqrt{f_1 f_2}$.

The bandwidth of a simple wire dipole depends on the wire thickness. Find the bandwidth for wire radii of 1mm, 2 mm, 5 mm, and 10 mm. You will have to change to the “extended thin wire kernel” for the thicker wires. Overplot the impedances of the four different wires on a Smith chart with markers at the band edges. Find the fractional bandwidth in each case. Make hard copies of the Smith chart and also a rectangular plot of VSWR.

Find the bandwidth of a folded dipole, referenced to $Z_0 = 300\Omega$ (the impedance of common twin-lead). Use a wire radius of 5 mm. How does that compare with a dipole of the same wire radius? Changing the reference impedance can broaden the bandwidth, particularly in this case. What is the broadest bandwidth you can get?