Thursday, February 15, 2022

EE 483/583 Antennas for Wireless Communications
Spring 2022 Laboratory 1- Linear Dipole

Background

For this project, you will use the Numerical Electromagnetics Code, Version 2 (NEC-2) to model a linear dipole antenna. Assume the dipole is placed along the z-axis in free space, centered & driven at origin, and made of 20 AWG (diameter $= 2a$) tinned copper wire ($\sigma = 3 \times 10^7$ S/m) of total length $\ell = 30$ cm.

Project

1) Draw the problem geometry (CAD drawings are OK).
2) Write a NEC-2 input file to model this antenna and determine the first resonant frequency (dipole is resonant when the input reactance is zero). To do this, sweep the input frequencies from $\ell/\lambda = 0.25$ to $\ell/\lambda = 0.75$ in steps of $\Delta\ell/\lambda = 0.025$. Select segment length(s) Δ that will work at all the frequencies. Clearly justify your selection. On a single graph, plot the antenna input resistance R_A and reactance X_A versus ℓ/λ. Near the resonant frequency, run frequency sweep(s), in smaller steps, to find the resonant frequency (f_r & ℓ/λ_r) to within $\ell/\lambda = 0.0001$ or $|X_A| < 0.01\ \Omega$, whichever is smaller. On another graph, plot a "close-up" of R_A & X_A versus ℓ/λ. List f_r (MHz), ℓ/λ_r, and $Z_{in,r}$.

   Note 1: The **input NEC files** should be included in the logbook **where used.** The output NEC files should be provided on a CD or USB flash drive. The output filenames and disk identifier(s) should be part of the lab write-up, but need not be included in hard copy form.

   Note 2: ℓ/λ is called the normalized frequency. Using $c = f\lambda$, we see that $\ell/\lambda = \ell f/c$ where $c = 2.998 \times 10^8$ m/s is the speed of light in free space used by NEC-2.
3) At $\ell/\lambda = 0.25$, ℓ/λ_r, 0.5, & 0.75 (rows), list in a table (columns): frequency f (MHz), normalized frequency ℓ/λ, input resistance R_A (Ω), $R_{r,in}$ (Ω), $R_{L,in}$ (Ω), input reactance X_A (Ω), input impedance magnitude $|Z_A|$ (Ω), & input impedance angle $\angle Z_A$ (deg). Use information given in the NEC output file to calculate the input radiation resistance $R_{r,in}$ and loss resistance $R_{L,in}$. [Hint: look at power information & $|I_{max}|$]. In a separate table, find and list: f (MHz), ℓ/λ, R_A (Ω), X_A (Ω), input reflection coefficient Γ_A (polar form w/ angle in degrees), and impedance mismatch loss (unitless and dB) at these frequencies if the antenna is connected to 75 Ω transmission line. **SHOW ALL WORK.**
4) At $\ell/\lambda = 0.25$, ℓ/λ_r, & 0.75, write NEC-2 input file(s) to find the current distribution along the antenna. On three (3) **separate** graphs (one per ℓ/λ), plot the real and imaginary components of the current, normalized by the maximum current magnitude along the antenna at that frequency, versus z/ℓ. Then, plot the normalized magnitude of the current versus z/ℓ (3 separate graphs), and phase (deg) of the current versus z/ℓ (3 separate graphs) at each frequency. On each plot, give $|I_{max}|$.
5) At $\ell/\lambda = 0.25$, ℓ/λ_r, & 0.75, write NEC-2 input file(s) to determine the elevation (E-plane, versus θ) and azimuthal (H-plane, versus ϕ) power gain radiation patterns (dBi). On **two** (2) polar graphs, one for the three elevation (E-plane) traces and one for the three azimuthal (H-plane) traces, plot the individually **normalized**/relative power gain radiation patterns versus angle in degrees (see Fig. 4.6 in the text) scaled so that the center of the plot is at –30 dB, the outer ring is at 0 dB, and 0° is at the top. Properly annotate the plots. In a table, list frequency f (in MHz), ℓ/λ, maximum power gain(s) (dBi), angle θ_{max} (deg) at which it occurs, and the HPBWs (deg) in the E-plane.
6) Summarize and comment on significant results.

Due Monday, February 28, 2022 at my office or mail box in EE department office by 4 pm.