EE 483L/583L Antennas for Wireless Communications
Spring 2024 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. Place the dipole along the z-axis in free space, centered & driven by a 1 V source at the origin, and made with 16 AWG (diameter $= 2a$) copper wire ($\sigma_{cu} = 5.7 \times 10^7$ S/m) of total length $\ell = 40$ 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 Δ that will work at all the frequencies. Clearly justify your selection. [Hint: Choose Δ near geometric mean of range, i.e., $\Delta \simeq \sqrt{\Delta_{min}\Delta_{max}}$.] 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. List f_r (MHz), ℓ/λ_r, and $Z_{in,r}$.

   Note 1: The **input NEC files** should be included in the report **where used.** The output NEC files should be provided on a USB flash drive. The output filenames should be included in the report, but need not be included in hard copy form.

   Note 2: ℓ/λ is the normalized frequency. Using $c = f\lambda$, $\ell/\lambda = \ell f/c$ 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), and input impedance magnitude $|Z_A|$ (Ω) & angle $\angle Z_A$ (deg). [Hint: Use information given in the NEC output file to calculate the input radiation resistance $R_{r,in}$ and loss resistance $R_{L,in}$, e.g., 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) if the dipole is connected to 75 Ω transmission line. **EE 583 only:** Find R_r and R_L at $\ell/\lambda = 0.75$. [Hint: $|I|_{max}$ is NOT at the origin.] **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 dipole at that ℓ/λ, versus z/ℓ. Then, plot the normalized magnitude of the current versus z/ℓ (3 separate graphs). [**EE 583 only:** Plot the phase angle (deg) of the current versus z/ℓ (3 separate graphs).] On each plot, give $|I_{max}|$. Each set of graphs should be on the same report page. Be careful, NEC gives current locations in terms of λ.

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 (columns), list frequency *f* (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.

<u>Report</u> (Due Tuesday, March 5, 2024 at my office or department mail box by 4 pm.)

- EE 483L- You may work independently or in pairs. EE 583L- You must work independently.
- The technical report should include: 1) Cover Page, 2) Introduction, 3) Body, 4) Summary & Conclusions, 5) References, and 6) Appendices (optional).
- The Cover Page should include *class*, *title*, *your name(s)*, and *date*.
- Introduction- tell reader what you covering in report. (Hint: Figures/pictures are useful.)
- Body should be broken down into **titled subsections** based on the different parts in order given.
- References should follow the IEEE system.
- Use professional font(s) (e.g., Times New Roman, Arial, …) of appropriate size (12 point or larger) and line spacing (e.g., 1.25 or 1.5) on fronts of pages only. It should be entirely electronically produced (i.e., use MS-Word or equivalent), no photos of handwritten items.
- Follow standard technical writing practices for units, lead zeros, etcetera.
- Put calculations, equations, results, and plots/figures in the **body** of the report as they occur. Appendices are **<u>NOT</u>** to be used as a "dumping ground" for these items. However, excerpts of output data files, computer code/m-files (not NEC input files) may be put in Appendices **if referenced in text** of the report.
- **All** tables/figures should be <u>captioned</u> (i.e., numbered and named).
- The report should be as long as necessary to cover the material, i.e., there is no specified length.
- Correct spelling and proper grammar will be considered in grading (part of being professional).