Thursday, March 7, 2024

EE 483L/583L Antennas for Wireless Communications
Spring 2024 Laboratory 2- Yagi-Uda Antenna Design

Background

For this project, design a Yagi-Uda antenna for a **locally available** **over-the-air** UHF television (TV) channel with a gain of 10 dBi or greater. Other specifications (implemented later) are that the antenna shall be fed, using a 50 Ω coaxial transmission line, such that the antenna has a VSWR < 1.1 at the center frequency and VSWR < 1.75 across the frequency band of the TV station. You will be building this antenna later using a 1/2" (I.D.) copper pipe boom. The first three elements will need to be length-adjustable, i.e., have telescoping tips that are slightly larger/smaller in diameter. Think practical!

Project

1) **Tabulate** specifications (e.g., UHF TV channel, frequency band, center frequency, etcetera).

2) Design a Yagi-Uda antenna, **without** a matching network or boom, to the specifications described above. For design purposes, assume elements are made of commercially-available brass ($\sigma_{brass} = 1.1 \times 10^7$ S/m) pipes. All work, including design figures and/or tables, should be included in a logbook and report, and chronicled in a fashion that another engineer can easily follow. As an initial estimate, let the length l_2 of the driven element be a simple average of the lengths of the reflector l_1 and first director l_3. Describe/justify all design choices. **Tabulate** length of all elements (0.xxxλ & cm).

3) Write and run a NEC-2 input file to find the input impedance and maximum gain G_{max} of your Yagi-Uda antenna at f_l , f_c, & f_h (low, center, & high frequencies of TV channel). Put antenna on the *y-z* plane ($x = 0$) with the elements parallel to the *y*-axis, reflector centered on origin, and driven & director elements spaced along the positive *z*-axis. Model the driven element as being center-fed. Iteratively adjust length l_2 of driven element until resonance is achieved (i.e., $|X_A| < 0.1$ Ω) at f_c. **Tabulate** results. Format- col. 1 l_2 (cm), col. 2 l_2/λ_c, col. 3 $Z_A(f_l)$, col. 4 $Z_A(f_c)$, col. 5 $Z_A(f_h)$, and col. 6 G_{max}.

   Note: After adjusting to resonance, l_2 may be less than l_3. For steps 3-6, use adjusted value of l_2 if $G_{max} \geq$ 10 dBi. If not, use the initial estimate.

4) Accurately draw resulting Yagi-Uda antenna with all relevant dimensions (in cm) included.

5) Write and run a NEC-2 input file to find the input impedance of the antenna over $f_c \pm 5$ MHz. Plot the input resistance R_A and reactance X_A versus frequency (MHz) on a single graph. Indicate f_l , f_c, & f_h. Also, find and **tabulate** the input impedance, radiation resistance, loss resistance, and efficiency at f_c.

6) At f_c, write and run a NEC-2 input file to determine the current distribution along each of the elements. On a single graph, plot the **normalized magnitude** of the currents versus element *y*-axis position (in cm). Normalize all currents by the maximum current magnitude (include in caption) on the **driven** element. **Clearly** label each curve by element, e.g., l_1 (reflector), l_2 (driven), l_3 (director 1), etcetera.

7) At f_c, write and run NEC-2 input file(s) to determine the far-zone E-plane (*y-z* plane) and H-plane (*x-z* plane) power **gain** radiation patterns (in dBi). On **two** polar graphs, plot the normalized/relative radiation patterns for the E-plane and H-plane scaled so that the center of each plot is at –40 dB and outer ring is at 0 dB with $\theta = 0°$ at the top. In a **table**, list the maximum power gain (in dBi), E-plane & H-plane HPBWs, maximum relative sidelobe levels (in dB), and front-to-back ratio/FB (in dB).

8) Summarize and comment on design and modeling results.

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<u>Report</u> (Report & logbook due Tuesday, March 19, 2023 at class.)

- 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.
- 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.
- Input NEC files and excerpts of output files should be included in the logbook & report as used. Complete input & output NEC files should be available on USB flash drives with relevant filenames provided in the logbook & report.
- 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, 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).