Tuesday, March 26, 2024

EE 483/583 Antennas for Wireless Communications
Spring 2024 Laboratory 3- Yagi-Uda Antenna Matching Design

Background

For this project, design a modified Gamma match for your Yagi-Uda antenna design of Laboratory 2. The goal is for the antenna to have a VSWR < 1.1 at the center frequency and VSWR < 1.75 across the frequency band of the UHF television (TV) station when fed using a 50 Ω coaxial transmission line.

Project

1) After any needed corrections and before matching, tabulate a summary of your ***no boom*** antenna design (channel, center frequency, # elements, lengths, spacings, etc.) with driven element length set for **resonance** at f_c. At the low f_l, center f_c, and high f_h frequencies (columns) of the selected UHF TV channel, find & tabulate (rows) input impedance Z_{in} (rectangular format) & reflection coefficient Γ_{in} (polar format), VSWR, mainbeam G_{max} & backlobe G_{back} gains (dBi), and front-to-back ratio/FB (dB).

2) At f_c, design a **modified Gamma match** for your Yagi-Uda antenna **without the boom**, i.e., NO boom length compensation & NO boom in NEC-2 model. At each step, detail & comment on design choices, e.g., what are you changing/selecting, values, and why. **SHOW ALL WORK*.** Tabulate a summary of your starting and final designs. (* For brevity, you can omit obviously wrong steps in report.)
   - For design/modeling purposes, assume the elements and modified Gamma match are made of commercially-available brass ($\sigma_{brass} = 1.1 \times 10^7$ S/m) pipes.
   - In the NEC-2 model(s), place the antenna on the *y*-*z* plane w/ elements parallel to *y*-axis.
   - Let the modified Gamma match portion of the driven element (modeled as wire of equivalent radius a_e) start at $y = 0$ and go to $y = l'/2$. To attempt to partially account for the use of a boom on a physical antenna, place the feed at the **second segment** out from $y = 0$ on the modified Gamma match portion of the driven element, make $\Delta \leq 1$ cm and use the EK 0 command in NEC-2 model.
   - Input NEC-2 file(s) and relevant excerpts of output file(s) should be included in logbook/report as used. Modeling choices should be explained and justified (e.g., selection of segment length Δ).

3) Write a NEC-2 input file to determine Z_a, G_{max}, and G_{back} for your matched antenna at f_l, f_c, & f_h. Calculate the FB ratio, Z_{in}, Γ_{in} (polar format) and VSWR at each frequency. For these frequencies (columns), **tabulate** Z_{in}, Γ_{in}, VSWR, G_{max}, G_{back}, and the FB ratio (rows). Discuss how they compare to the un-matched antenna. Comment on the VSWR at the band edges. Does it meet the specifications?

4) Using Fig 10.26 (include in logbook/report), compute the boom compensation at f_c. Assume the boom diameter D is either 9/16" or 5/8" (typical outer diameters for common 1/2" copper pipe). Apply the full boom compensation to the element lengths found after steps 1 & 2, and apply half the boom compensation to the modified Gamma match length. Tabulate the resulting elements lengths l_i, spacings s_{ij}, & diameters $2a$, modified Gamma match length $l'/2$, spacing s, and diameter $2a'$. The table should have three columns- column 1 is variable description/label, column 2 is values (cm) without boom compensation, and column 3 values (cm) with boom compensation.

5) Accurately draw the resulting antenna with the modified Gamma match and boom. Include all relevant dimensions (cm). Offset your modified Gamma match by $D/2 + \Delta y$ to avoid overlapping the boom. Assume $\Delta y = 2$ mm (slightly larger than the center conductor to shield spacing of a 50 Ω coaxial transmission line). It should be placed between the driven and reflector elements.

6) Summarize and comment on results.

Report

- 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*, and *date*.
- Introduction- tell reader what you covering in report. (Hint: Figures/pictures are useful.)
- The Body should be broken down into **titled subsections** based on the different parts.
- 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.
- For legibility/readability, code listings/tables/figures should avoid dark backgrounds and take the full width of the page.
- **All** tables/figures should be captioned (i.e., numbered and named).
- References should follow the IEEE system.
- Correct spelling and proper grammar will be considered in grading (part of being professional).
- Put calculations, equations, NEC-2 input files* & output file excerpts, results, and plots/figures in the **body** of the report as they occur. Appendices are **NOT** to be used as a "dumping ground" for these items. However, NEC-2 segmentation calculations and computer code/m-files may be put in Appendices **if referenced in text** of the report. [* For matching iterations, minor changes to NEC-2 input files can be given by just the lines affected and a reference to the original file. A full listing of the initial and final input files should be included]
- The report should be as long as necessary to cover the material, i.e., there is no specified length.

Report & logbook due Tuesday, April 2, 2024 by 4 pm at my office.