

EE 483/583 Antennas for Wireless Communications

Spring 2024 Laboratory 4- Yagi-Uda Antenna Construction & Matching

Background

For this project, you or your team (2 students maximum) will construct and impedance match a Yagi-Uda antenna, designed in previous labs, for a local UHF television (TV) station. It should have a gain ≥ 10 dBi, and VSWR < 1.1 at center frequency and VSWR < 1.75 across the frequency band of the selected UHF TV station when fed using a $50\ \Omega$ coaxial transmission line (supplied by instructor).

Project

After consulting with instructor, buy parts, and build the antenna, including the matching network, per your design to meet the specifications listed above. See instructor for tools & help. Comment on and describe all work, especially any changes from original design. Some items to consider/do are:

- Start with a tabulated summary of the initial matched & boom-compensated design (post Lab #3).
- Do the diameters, lengths, centering, spacing, and alignment of boom & elements as well as matching network of the antenna actually built conform to exactly to this initial design? If not, detail adjustments/changes being made. (e.g., telescoping pieces, changes in s , ...)
- Is the boom long enough to attach antenna to an antenna mast without interference?
- Is antenna mechanically sturdy? I.e., Can it withstand the *finger nail* & '**FAT PIGEON**' tests?
- Is the antenna presentable to a customer? (consider cleanliness, sharp edges, ...)
- Tabulate estimated costs and parts list. The table should have columns listing: description of item(s), purchased quantity, overall cost (exclude taxes), estimated quantity used, estimated pro-rated cost (i.e., cost of materials actually used), and supplier(s) with addresses. E.g., if you need 18 inches of 1/8 inch pipe, but the minimum length available is 36 inches costing \$6, itemize the 36-inch pipe & cost (\$6), amount used (18 inches) & pro-rated cost ($18/36 * \$6 = \3). The coaxial cable and BNC connector will be supplied by the instructor (i.e., SDSM&T EECS department is the supplier). Go on-line to estimate the cable cost (e.g., Amazon). You do not need to list lab/shop materials (e.g., solder, paste flux, ...). At the bottom of the table, give the total estimated cost & pro-rated cost of the antenna.

Experiment (By appointment. I will be gone noon 4/18 through Sunday 4/21/24 for SDAoS meeting.)

- 1) Before making any matching adjustments to the antenna (i.e., set all lengths to design values), work with instructor to use a vector network analyzer (VNA) to collect data and/or graphs needed to plot VSWR, linear magnitude of the reflection coefficient (AKA $|S_{11}|$), and antenna input impedance Z_{ant} (both Smith chart and rectangular format) for $f_c \pm 10\ \text{MHz}$ (f_c is the center frequency of your antenna).

Note: The names of the data/graphics files should be recorded in the logbook as taken. The actual files should be available in/with logbook (e.g., USB flash drive).

- 2) Using the VNA, match the antenna with instructor assistance. Collect the data and/or graphs needed to plot the VSWR, $|S_{11}|$, and Z_{ant} (both Smith chart and rectangular format) for $f_c \pm 10\ \text{MHz}$.
- 3) On four consecutive pages in logbook & report, generate (show applicable equations if necessary) and insert four pairs of plots showing the: 1) VSWR, 2) $|S_{11}|$, 3) Z_{ant} in Smith chart format, and 4) Z_{ant} in rectangular format before (top) and after (bottom) matching for $f_c \pm 10\ \text{MHz}$. On the plots, indicate the lower f_l , center f_c , and high f_h frequencies of the selected UHF TV channel.
- 4) Accurately draw the **actual** antenna after construction **and** matching, include all relevant dimensions (e.g., telescoping tips). Compare and contrast the actual antenna with the preliminary design.
- 5) Summarize/comment on results.

Logbook (not a mystery, just ask if you have questions!)

- Bound logbook (**NO** spiral bound notebooks).
- On cover, **prominently** put **EE 483L/583L Antennas, Spring 2024**, and *your name(s)*.
- **All** entries should be in **ink** (black/blue preferred) and **only on the fronts of pages**. Backs of pages may be used as scratch paper. **No** pencil entries, erasing, obliterating, or using white-out.
- Make a **Table of Contents** (TOC) on the first page with labeled columns- Lab number, Lab Title, Date(s), and Page numbers (**both** start-finish).
- **All pages** in logbook should be consecutively numbered in upper right-hand corner. **Never** tear out pages, have loose pages/materials, have material overhanging logbook pages, or insert multiple pages that are not individually attached to logbook pages.
- Start each lab by attaching the lab assignment sheet in the logbook. For experimental work, **lab partner(s), equipment list** (description, brand, & model #s), time(s) & date(s) ... should be listed, as applicable. Test configurations(s) used for measurements should be drawn/specified.
- Writing/figures/graphs must be **legible** (spread out, don't squish lines together) and of a **readable** size.
- Figures/tables/graphs should be captioned (number & title), labeled (i.e., names & units on axes), scaled, and clearly drawn. They can be electronically generated and taped/pasted into logbook. The bottoms of figure/graph/table(s) should be oriented toward the bottom or right-hand side of the page.
- Use conventional engineering units & prefixes (i.e., MKS). For example, 1.253 mW and 100 MHz **not** 0.001253 W and 10^5 kHz. Answers with missing or incorrect units are incomplete/incorrect.
- Answers should be boxed/double underlined, in **decimal** format if a number (no fractions) with variables, values & units (if any) included. Also, use lead zeros for fractional answers. For example, " $V_x = 0.4 \text{ V}$ " **not** " $V_x = .4$ " or " $V_x = 2/5 \text{ V}$ ". Typically, 4-5 significant digits are used.

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 **body** of the report as they occur. Appendices are **NOT** to be used as a "dumping ground" for these items. NEC-2 segmentation calculations and computer code/m-files may be put in Appendices **if referenced in text**. [* 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.

Logbook, report, and antenna due Monday, April 22, 2024 at my office by 3 pm.