Tuesday, March 8, 2022

EE 483/583 Antennas for Wireless Communications
Spring 2022 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 such that the antenna has a VSWR < 1.1 at the center frequency and VSWR < 1.8 across the frequency band of the TV station when fed using a 50 Ω coaxial transmission line. 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., telescoping tips that are slightly larger/smaller in diameter). Think practical!

Project

1) Design a Yagi-Uda antenna, **without** a matching network or boom, to the specifications described above. Tabulate specifications (e.g., UHF TV channel, frequency band, center frequency f_c, directivity/gain, …). 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 logbook & report, and chronicled in a fashion that another engineer can easily follow. As an initial estimate, let the length l_2 of 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 the length of all elements (0.xxxλ & cm).
2) Write and run a NEC-2 input file to find the input impedance and G_{max} of your Yagi-Uda antenna at f_l, f_c, and f_h (low, center, & high frequencies of TV channel). Place the antenna on the y-z plane ($x = 0$) with the elements parallel to the y-axis, reflector centered on the 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 initial estimate.
3) Accurately draw resulting Yagi-Uda antenna with all relevant dimensions (in cm) included.
4) 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 (in 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.
5) 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 on the **driven** element. Clearly label each curve by element, e.g., l_1 (reflector), l_2 (driven), l_3 (director 1), etcetera.
6) 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 power radiation patterns for the E-plane and H-plane scaled so that the center of each plot is at –40 dB and the outer ring is at 0 dB. Place $\theta = 0°$ 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).
7) Summarize and comment on design and modeling results.

   Note: 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.

Technical report and logbook due Wednesday, March 23, 2022 at class.