♣ Friday, March 17, 2017 ♣

EE 483/583 Antennas for Wireless Communications
Spring 2017 Laboratory 2- Yagi-Uda Antenna Design

Background

For this project, you will be designing 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 (supplied by instructor) in a manner such that the VSWR < 1.2 across the frequency band of the TV station. Keep in mind that 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** the matching network or boom, to the specifications described above. Tabulate specific choices (e.g., TV channel, frequency band, center frequency f_c, directivity/gain, …) For design purposes, assume the elements are made of commercially-available brass ($\sigma_{brass} = 1.1 \times 10^7$ S/m) pipes. All work, including any design figures and/or tables, should be included in logbook, and chronicled in a fashion that another engineer could easily follow. As an initial estimate, let the length l_2 of driven element be the simple average of the lengths of the reflector l_1 and first director l_3. Describe and justify design decisions.

2) Write a NEC-2 input file to determine the input impedance 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- column 1 l_2 (cm), column 2 l_2/λ_c, column 3 $Z_A(f_l)$, column 4 $Z_A(f_c)$, and column 5 $Z_A(f_h)$.

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

4) Over $f_c \pm 5\%$, write a NEC-2 input file to determine the input impedance of the Yagi-Uda antenna. 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, and loss resistance at f_c.

5) At f_c, write 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. Label each curve by element, e.g., l_1 (reflector), l_2 (driven), l_3 (director 1), etc.

6) At f_c, write 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 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: The input NEC files should be included in the logbook as used. The complete output NEC files should be available on USB flash drives/CD with relevant filenames and/or disk identifier(s), but need not be included in hard copy form.

Due Friday, March 24, 2017 at class.