## EE 483L/583L Antennas for Wireless Communications (Spring 2025)

## Laboratory 4- Rhombic Antenna Modeling

**Introduction**

In this laboratory, you will use the Numerical Electromagnetics Code, version 2 (NEC-2) to model a rhombic antenna, shown in Figure 1, located on *x-z* plane symmetrically about *z*=0. Rhombic antennas were popular broadband antennas prior to WW II. Post WW II, they were largely supplanted by other antenna types, e.g., log periodic dipole arrays (LPDAs).



**Figure 1** Rhombic antenna geometry (not to scale)

**Project** (work individually)

To drive the antenna, place a 1∠0° V voltage source centered on section 1. Model section 1 as being made with copper wire with length of 2*h* = 0.4”, diameter of 0.05”, and conductivity of 5.7×107 S/m. Model the remainder of the antenna as being made of 16 AWG copper wire with a conductivity of 5.7×107 S/m. Section 6 will be the same length as section 1. Sections 2-5 (AKA: legs) will each have a leg length *L* = 110 mm. Set the rhombic half angle *a* = 36°. The antenna is terminated with a resistive load 2*RT* = 600 W, spread over two segments on section 6 on either side of *z* = 0. We’ll model over the frequency range 2500 to 8500 MHz. To agree with NEC-2, let *c*=2.998×108 m/s.

* 1. Using geometry and trigonometry, find the points *Pij* where the sections connect as well as the lengths *li* of sections 1-6. Clearly show work in a section/appendix titled ‘Geometry Calculations’. Keep up to 5-6 significant figures. Use units of **meters**.

*P*12 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ *P*14 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*P*23 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ *P*45 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*P*36 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ *P*56 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*l*1 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ *l*2 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ *l*3 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*l*4 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ *l*5 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ *l*6 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* 1. For sections 1, 2–5, & 6, find the wire radius *ai* (m). Then, select the number of segments *Ni* and segment lengthsD*i* (m). Note: Segment lengths may or may not be equal. Restriction: Do NOT exceed **250 segments** in total. Justify design decisions in a section/appendix titled ‘Segment Selection’. List total number of segments *N*tot. Is the extended thin-wire kernel needed? Why?

|  |  |  |  |
| --- | --- | --- | --- |
| Section | 1 | 2-5 | 6 |
| *ai* |  |  |  |
| *Ni* |  |  |  |
| D*i* |  |  |  |

Total # segments = *N*tot = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

EK? Yes / No Why? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* 1. Use work in prior steps as the basis to write a NEC-2 input file to collect input impedances from 2500 MHz to 8500 MHz in steps of 50 MHz. [Hints: Use EX command flag I4 to tabulate *Z*in data. The nec2dxs1K5.exe program limits the table length to 40 frequencies.] Then, create rectangular plots of resistance (W) versus frequency (MHz) and reactance (W) versus frequency (MHz). Insert plots in logbook/report. Comment on how *Z*in varies with frequency.
	2. Write a NEC-2 input file to collect the boresight (*q* = 90°, *f* = 0) gain and efficiency from 2500 MHz to 8500 MHz in steps of 500 MHz. Then, create a rectangular plot of gain (dBi) versus frequency (MHz) and efficiency (%) versus frequency (MHz). Insert plots in logbook/report. Comment on how the gain and efficiency vary with frequency. E.g., what are the highest values and at what frequencies do they occur? How long is *L* in terms of l at *G*max?
	3. At the frequency where the gain is highest, write a NEC-2 input file(s) to collect the elevation/E-plane (i.e., *x-z* plane) gain radiation pattern letting -179° ≤ *q* ≤ 180° in 1° steps w/ *f* = 0. Then, create a normalized polar radiation pattern plot (*q* = 0 at top, clearly labeled, in dB, & with center at -35 dB). Insert plot in logbook/report. Find the maximum gain (dBi) and elevation angle at which it occurs. Also, find the half-power beamwidth HPBWE (deg) in the E-plane.
	4. At the frequency where the gain is highest, write a NEC-2 input file(s) to collect the azimuthal/H-plane (i.e., *x-y* plane) gain radiation pattern letting *q* = 90° w/ 0 ≤ *f* ≤ 359° in 1° steps. Then, create a normalized polar radiation pattern plot (*f* = 0 at right, clearly labeled, in dB, & with center at -35 dB). Insert plot in logbook/report. Find the maximum gain (dBi) and azimuthal angle at which it occurs. Also, find the half-power beamwidth HPBWH (deg) in the H-plane.
	5. **EE 583 only:** The radiation pattern of the rhombic antenna begins to deteriorate at lower frequencies, i.e., the maximum gain no longer occurs at boresight. To within 100 MHz, determine the lowest frequency *f*low (MHz) where the maximum gain is at boresight. How long is *L* in terms of l at *f*low? [Hint: Radiation pattern first deteriorates in the azimuthal direction.]

**Report**

* Show initial work in logbook. Following syllabus guidelines, compose a short report on this lab.

**Logbook and report due Monday, March 3, 2025 at class.**