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).

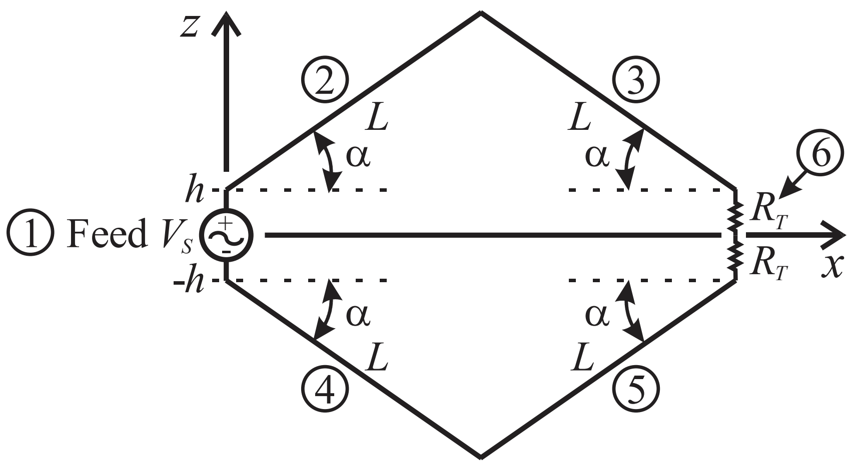

Figure 1 Rhombic antenna geometry (not to scale)

Project (work individually)

To drive the antenna, place a $1\angle 0°$ V voltage source centered on section 1. Model section 1 as being made with copper wire with length of $2h = 0.4$", diameter of 0.05", and conductivity of 5.7×10^7 S/m. Model the remainder of the antenna as being made of 16 AWG copper wire with a conductivity of 5.7×10^7 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 $\alpha = 36°$. The antenna is terminated with a resistive load $2R_T = 600\ \Omega$, 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 $c = 2.998\times10^8$ m/s.

1) Using geometry and trigonometry, find the points P_{ij} where the sections connect as well as the lengths l_i 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 = __________

2) For sections 1, 2 – 5, & 6, find the wire radius a_i (m). Then, select the number of segments N_i and segment lengths Δ_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
a_i			
N_i			
Δ_i			

Total # segments = N_{tot} = ______________

EK? Yes / No Why? ____

3) 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 (Ω) versus frequency (MHz) and reactance (Ω) versus frequency (MHz). Insert plots in logbook/report. Comment on how Z_{in} varies with frequency.

4) Write a NEC-2 input file to collect the boresight ($\theta = 90°$, $\phi = 0$) 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 λ at G_{max}?

5) 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 $-179° \le \theta \le 180°$ in 1° steps w/ $\phi = 0$. Then, create a <u>normalized</u> polar radiation pattern plot ($\theta = 0$ 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 $\mathrm{HPBW_E}$ (deg) in the E-plane.

6) 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 $\theta = 90°$ w/ $0 \le \phi \le 359°$ in 1° steps. Then, create a <u>normalized</u> polar radiation pattern plot ($\phi = 0$ 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 $\mathrm{HPBW_H}$ (deg) in the H-plane.

7) **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 λ at f_{low}? [Hint: Radiation pattern first deteriorates in the azimuthal direction.]

<u>Report</u>

- 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.