EE 483L/583L Antennas for Wireless Communications (Spring 2026)
Laboratory 5- Rhombic Antenna Input Measurements

Introduction

In this laboratory, you will use the network analyzer to measure the input impedance of a rhombic antenna, shown in Figure 1, located on the *x*-*z* plane above a ground plane at $z = 0$.

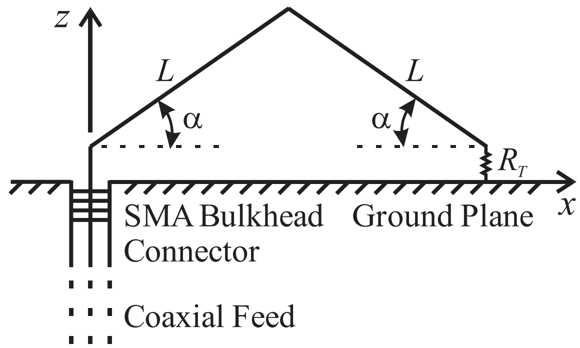

Figure 1 Rhombic antenna geometry (not to scale)

Experiment (You may work in groups of two. Bring logbook and USB drive.)

1) The instructor will have the rhombic antenna, ground plane, 6' coaxial cable, adapters, Keysight E5063A vector network analyzer (VNA), Agilent 85033E 3.5mm Calibration Kit, caliper, ruler, tape measure, protractor, etc. available. Include an **equipment table** with all relevant equipment information in logbook, i.e., description, manufacturer, and model number (as applicable).
2) Take **picture(s)** showing the antenna and ground plane. Insert in logbook.
3) Measure relevant dimensions and parameters of the physical rhombic antenna.
4) If necessary, power on the VNA. Connect a Type N (m) - SMA (f) adapter and the 6' coaxial cable to Port 1 of the VNA.

Wear a static wristband whenever working with the VNA!

Torque coaxial connections using torque and box wrenches (mechanical support)!

5) To begin, select the frequency range and settings for the VNA. The frequency should range from 2.5 GHz to 8.5 GHz in steps of 25 MHz. Calculate and record the number of data points N_{dat} required. Use data averaging with an averaging factor of 8. Press the Format button and use the mouse to select <Smith> and then <R +jX> to display an impedance Smith chart.
6) Per earlier lab, calibrate the VNA to the reference plane of the SMA (m) connector on the open end of the coaxial cable.
7) Connect cable to the SMA (f) bulkhead connector below the ground plane. **Draw a block diagram(s) of the test set-up.**
8) The SMA (f) bulkhead connector introduces an electrical delay to the measurement. Set the electrical delay to $\mathbf{\Delta t_{delay} = 0.1}$ **ns**. [The instructor 'shorted' the center pin of the connector to the ground plane. Then, he activated Marker 1 and put it at $f_{mid} = 5.5$ GHz. For a short circuit, the marker should be at the 0 Ω point where $\Gamma = 1\angle\pm180°$ on the Smith chart. He used the <Electrical Delay> function of the VNA to move Marker 1 near the 0 Ω point. Then, he switched to the phase format display and refined the electrical delay so the phase was ±180°.]

9) With the display format set to an impedance Smith chart:
   - **Save a screen shot of the Smith chart display**. Leave room for screen shot in logbook.
   - **Save impedance Smith chart trace data.**

10) If no other groups are waiting, power down the VNA; else, push Preset button.

Analysis

1) How did the experimental rhombic antenna dimensions and parameters compare to those used for the NEC-2 simulation done in Lab 4?
2) Using **Matlab**, create two rectangular plots showing the resistance R versus frequency f (MHz) as well as the reactance X versus f. On each plot show **both** the NEC-2 (remember to convert from dipole to equivalent monopole values) and experimental/measured data. For resistance, use a vertical scale of $0 \le R \le 250\ \Omega$. For reactance, use a vertical scale of $-150 \le X \le 150\ \Omega$. Insert plots in the logbook. Comment on how the experimental and NEC-2 data compare.
3) Typically, the experimental data will be shifted with respect to the NEC-2 data while having similar shape. This shift is (mostly) due to not perfectly accounting for the electrical delay introduced by the SMA bulkhead connector, e.g., the solder joint between the SMA center pin and the wire adds to the 0.2” length. To ‘tweak’ the experimental data so that it aligns better, we will add an additional time delay (phase shift). To do this, you will modify your m-file from the prior step. You should have the resistance and reactance data as well as the corresponding frequencies for both the experimental/measured and NEC-2 (adjusted to monopole case) results. Suggested steps:
   a) Create complex vector of measured impedance Z_{exp} from R_{exp} and X_{exp}.
   b) Select/set a time-delay t_d. Hint: Expect $5 \le t_d \le 30$ ps.
   c) Calculate the complex vector of the reflection coefficients corresponding to Z_{exp}, e.g., $\Gamma_{\text{exp}} = \dfrac{Z_{\text{exp}} - Z_0}{Z_{\text{exp}} - Z_0}$.
   d) Calculate a complex vector of the time-delayed reflection coefficients at each of the experimental frequencies f_{exp}, e.g., $\Gamma_{\text{delay}} = \Gamma_{\text{exp}} e^{-j\omega t_d} = \Gamma_{\text{exp}} e^{-j2\pi f_{\text{exp}} t_d}$.
   e) Calculate the complex vector of impedances corresponding to the time-delayed reflection coefficients, e.g., $Z_{\text{delay}} = Z_0 \left[\dfrac{1+\Gamma_{\text{delay}}}{1-\Gamma_{\text{delay}}} \right]$.
   f) Create two rectangular plots showing the resistance versus frequency as well as the reactance versus frequency. On each plot show **both** the NEC-2 data (convert dipole impedance to equivalent monopole impedance) and time-delayed experimental data. Use same vertical scales as in the prior step.
   g) Iteratively repeat prior steps for different time-delay t_d values until you get the best agreement between the R and X traces (‘eye-ball’ accuracy sufficient). Insert these plots in the logbook with ***best-case t_d*** noted in the caption.

Report and Logbook

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

Report and logbook due by Friday, March 13, 2026 at class.