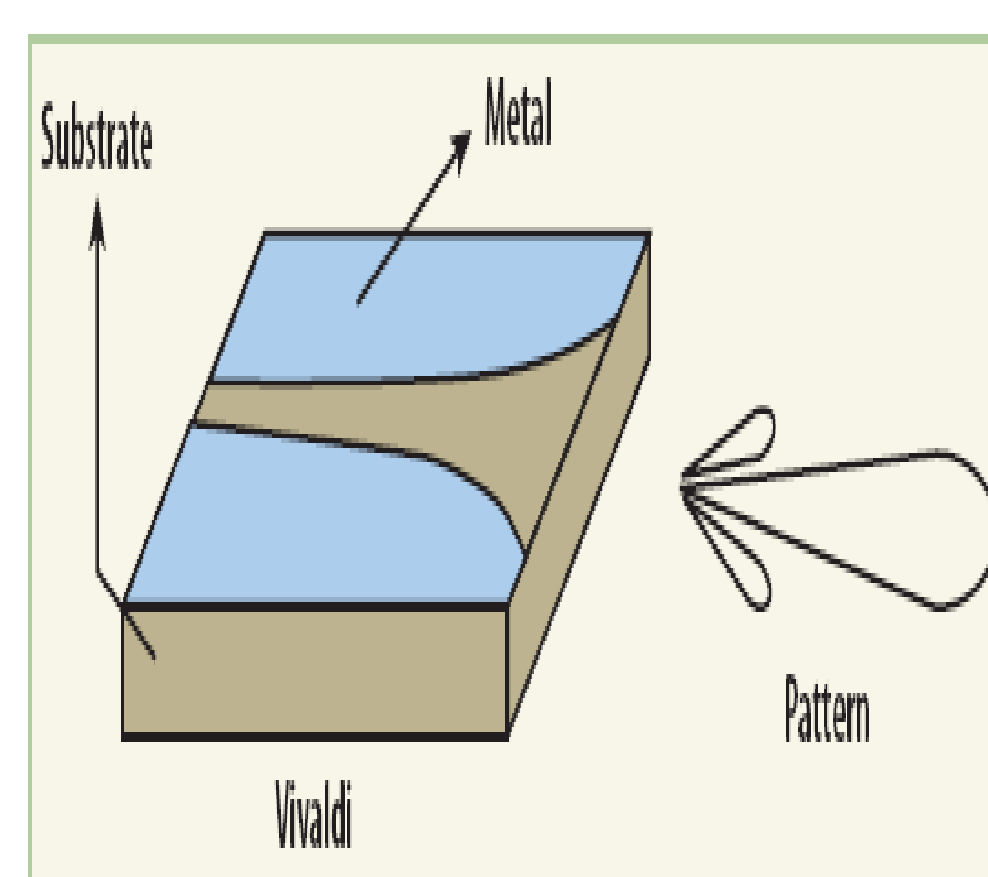


Objective

This project is to study the process of creating Vivaldi wire antennas using direct write technology. The goal is to use less material and fabrication time to achieve performance similar to the typical tapered slot design (below). These antennas are printed on a flexible polyimide substrate. To assess how the antennas perform, they are compared to a vee antenna of the same wire length. We are using MATLAB, AutoCAD, Numerical Electromagnetic Code (NEC-2), and Microsoft Excel software to complete the design, simulation, fabrication, and testing of the antennas



Vivaldi antenna tapered slot design. This is the typical design for a Vivaldi antenna. Material is removed to form a slot in the conductive material. This process requires more material and can take longer to complete.

This image from <http://mwrf.com/>

Procedure

Phase 1- Design

- MATLAB
 - This software was used to calculate the X and Y coordinates of the points along the exponential curve that gives the Vivaldi antenna its shape.
 - The equation $y(x)=A*e^{(p*x)}$ was taken from the publication Gibson, P. (1979). The Vivaldi Aerial. *9th European Microwave Conference, 1979.*
- AutoCAD
 - Using MATLAB results, AutoCAD script files were created.
 - These files were used to draw the antenna for printing.

Phase 2- Simulation

- NEC-2
 - This software, based on the Method of Moments, simulated dipole versions of the antennas both with and without resistive loading.
- Microsoft Excel
 - This software was used to catalog data values from the NEC software for use in MATLAB.

- MATLAB
 - MATLAB was used to plot and display simulation data.
 - This data was analyzed to decide which antennas should be fabricated.

Phase 3-Fabrication

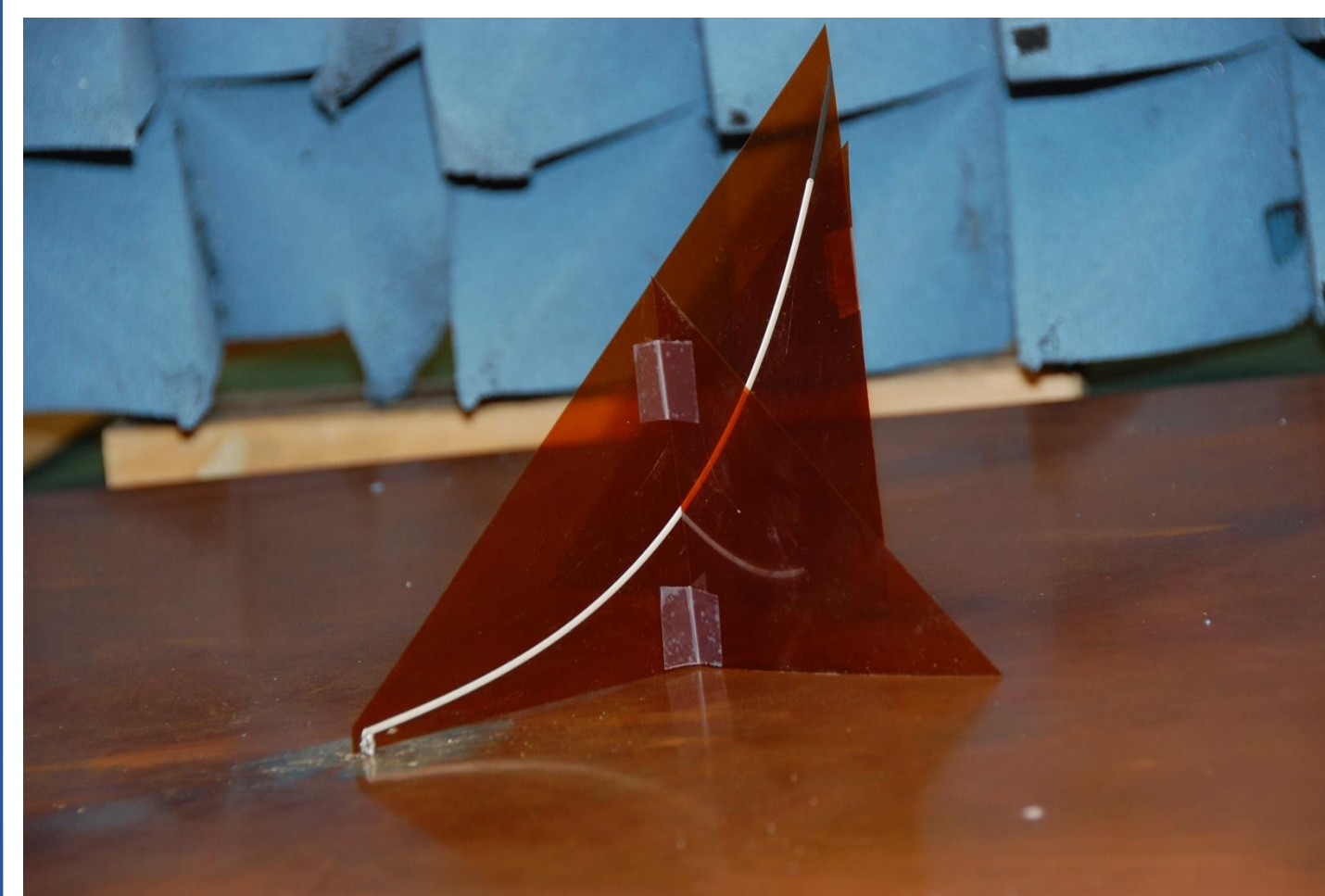
- nScript 600-3Dn-HP machine
 - This machine was used to deposit the Goldstone 3100 (resistive) and 6130F (conductive) inks from Methode Development onto the polyimide substrate.
- Omegalux LMF-3350, oven used to cure ink traces.
 - The curing time for the traces was 90 minutes at a temperature of 138⁰ C.
- Caution had to be used as polyimide cannot be heated above 250⁰ C. Later, this was considered when soldering antennas to SMA test connector.



nScript machine in the direct print lab at South Dakota School of Mines & Technology. This machine will deposit the ink following our antenna profiles.

Phase 4- Testing

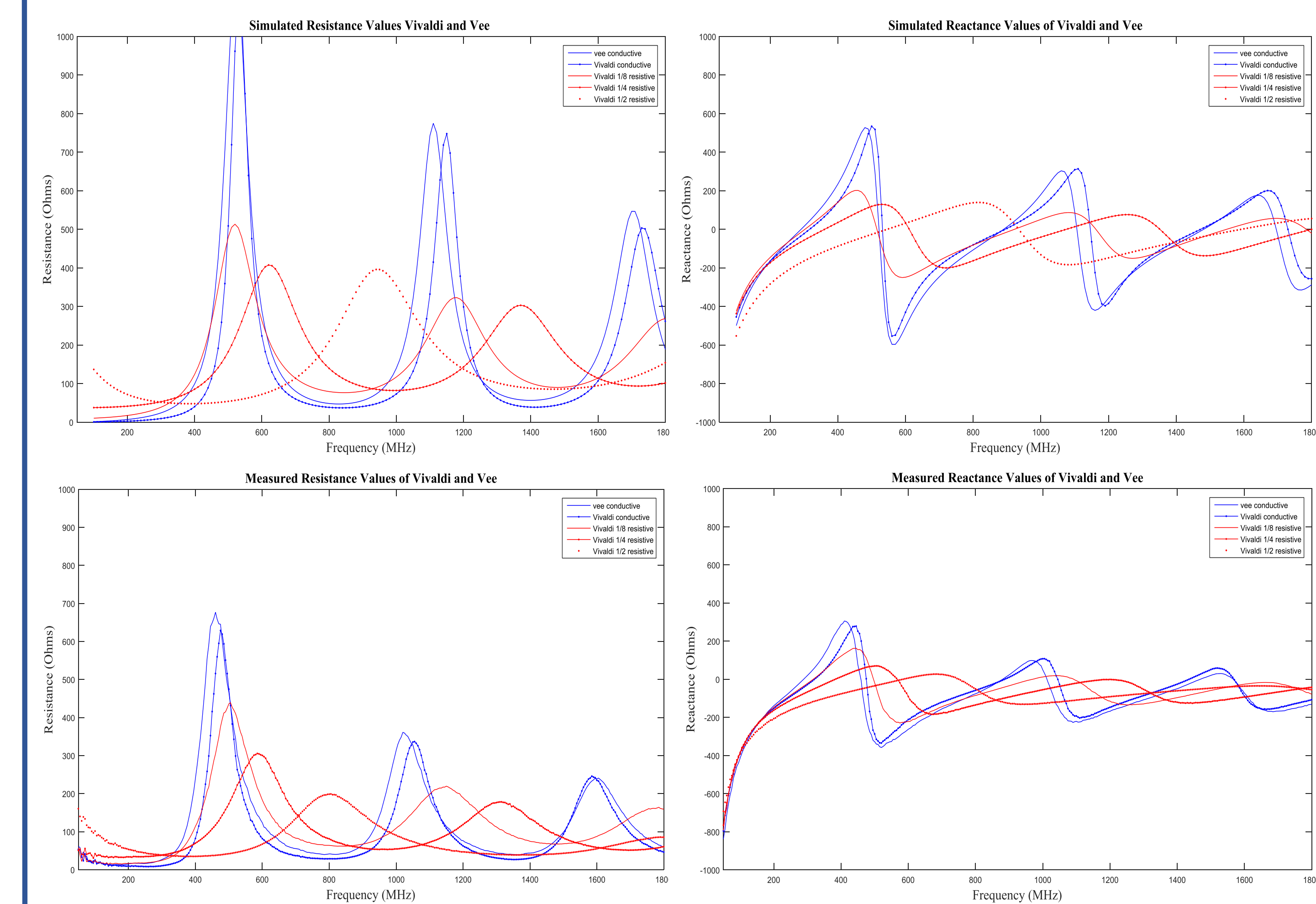
- Our finished antennas were tested on a ground plane.
- This allowed the use of monopole antennas fed by coaxial transmission lines.
- An Agilent 4396B Vector Network Analyzer (VNA) was used to measure the scattering parameter S11 (i.e., reflection coefficient) of the antennas versus frequency.
- MATLAB was used to calculate the input impedance of each antenna from the S11 data.



This is the testing setup used. Radiation absorbing carbon-loaded foam surrounded the area to reduce reflections. The ground plane is visible. However, the VNA is out of the frame.

Results

The input impedances of the fabricated antennas were measured and compared to simulation results. The simulation results were divided in half as the simulations were of dipoles and the tested antennas were monopoles over a ground plane. The graphs below show differences between the measured and simulated results. The simulations assumed perfect conductors for the conductive portions of the antennas. However, the 6130F ink is not a perfect conductor. To account for this, we will need to determine the conductivity of the ink in future work.



Conclusions

This project is a great educational experience. Based on initial analysis, simulation models need to be modified to account for the finite conductivity of the 6130F silver based ink. Once the conductivity is adjusted in the simulation software, the plots should be very similar. Further testing and simulations need to be performed to get the conductivity of our antenna traces.

Future work

- Perform tests to determine conductivity of antennas
- Design and manufacture more antennas to be tested
- Perform tests to establish a better print and cure process