Low-Cost VHF Antenna Final Presentation

ELECTRICAL [+] COMPUTER

ENGINEERING

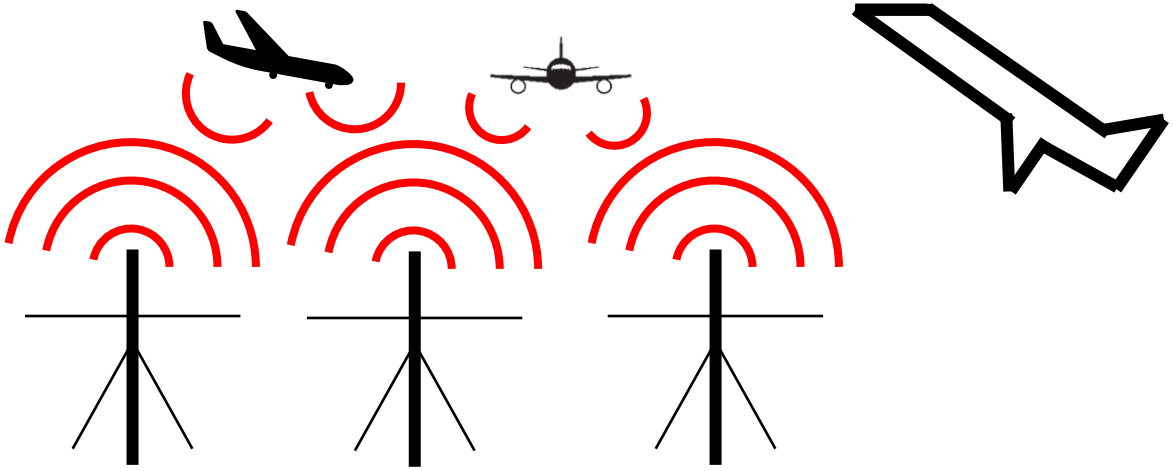
Georgia Tech School of Electrical and Computer Engineering

Agenda

- Overview
- Design Process
- Design
  - Antenna
  - RF Circuit
- Simulation
- Radar Analysis
- Prototyping
- Cost Breakdown
- Challenges
- Future Work

Overview

- Radar fence posts forming a line detecting objects crossing the threshold
- Stealth Aircraft are optimized for X and K_u frequency bands
- VHF band radar will allow for better detection of small targets due to resonance



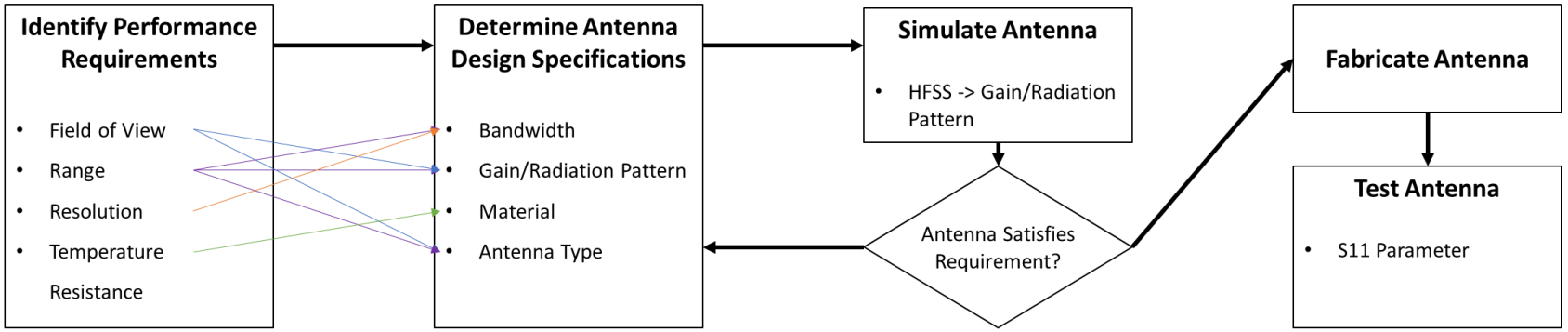
Problem Statement

- Design, prototype, and analyze a **cost-effective, durable antenna** to be used as part of a radar system operating in the **VHF band** to **accurately detect** small objects.

Objectives

- Detect small objects
  - Radar Cross Section (RCS) < $1m^2$
- Operate within VHF Band
  - f: $30MHz - 300MHz$
- Low Transmit Power
  - $P_t < 1W$
- Low Cost
  - Less than $10,000
- Maximize Range

Design Process

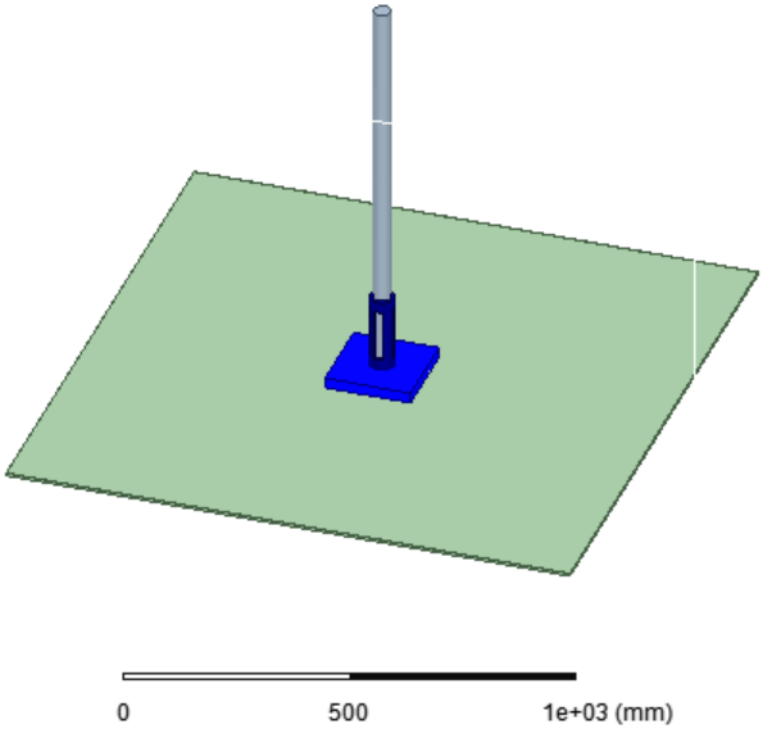


Key Equations:

- Range Equation: $R = \sqrt[4]{\frac{P_t \cdot G^2 \cdot \lambda^2 \cdot \sigma}{(4\pi)^3 \cdot S_{min}}}$
- Noise Equation: $N = kTB$
- Signal to Noise Ratio: $SNR = \frac{S_{min}}{N}$

Design – Antenna

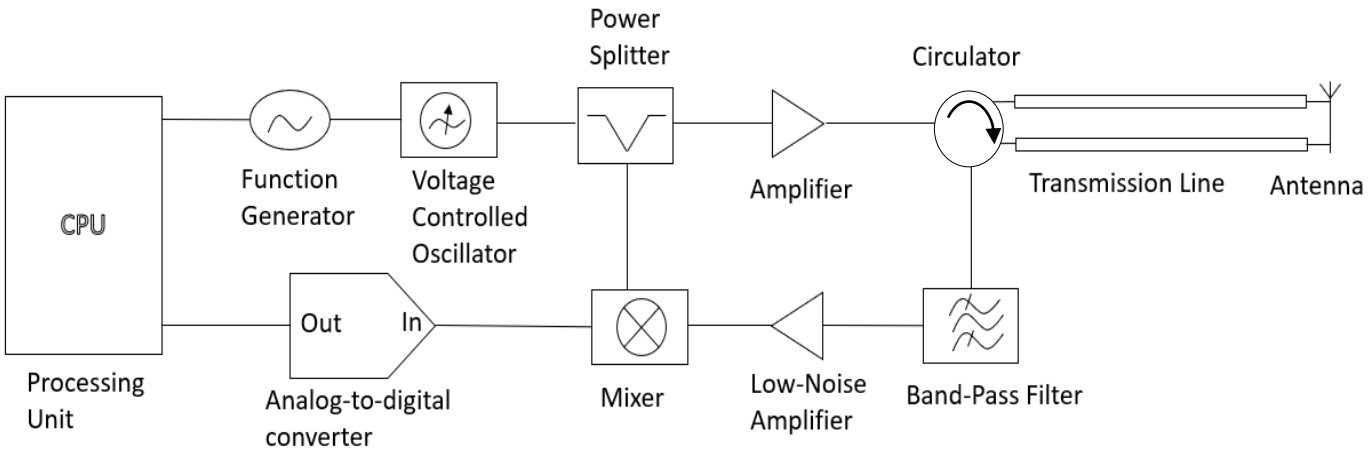
- 3/4 Monopole with a Ground Plane



3/4 Monopole with Ground Plane	
Frequency	224 MHz
Transmit Power	1W
Bandwidth	500 kHz
Material	Aluminum-6061
Height	0.96m
Width	1.22m

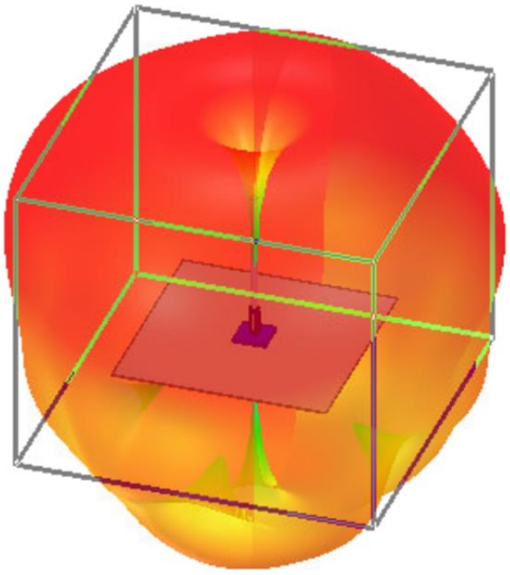
Design – RF Circuit

- Circuit for amplification, modulating, and processing of received signal

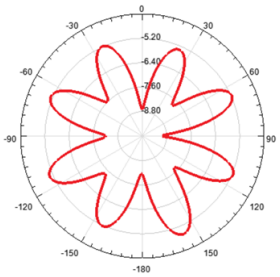


Simulations

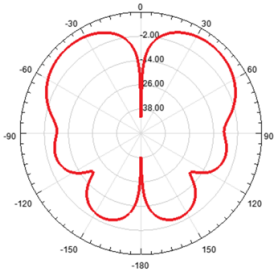
- High-Frequency Structure Simulator (HFSS) – Antenna
- Advanced Design System (ADS) – RF Circuit



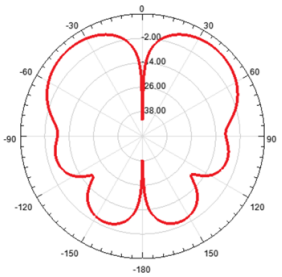
3D Gain Plot superimposed over Antenna Model



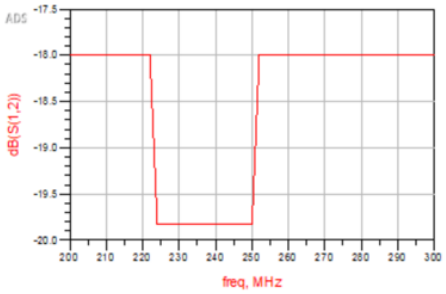
Azimuth Plane



Elevation Plane ($\theta = 0°$)



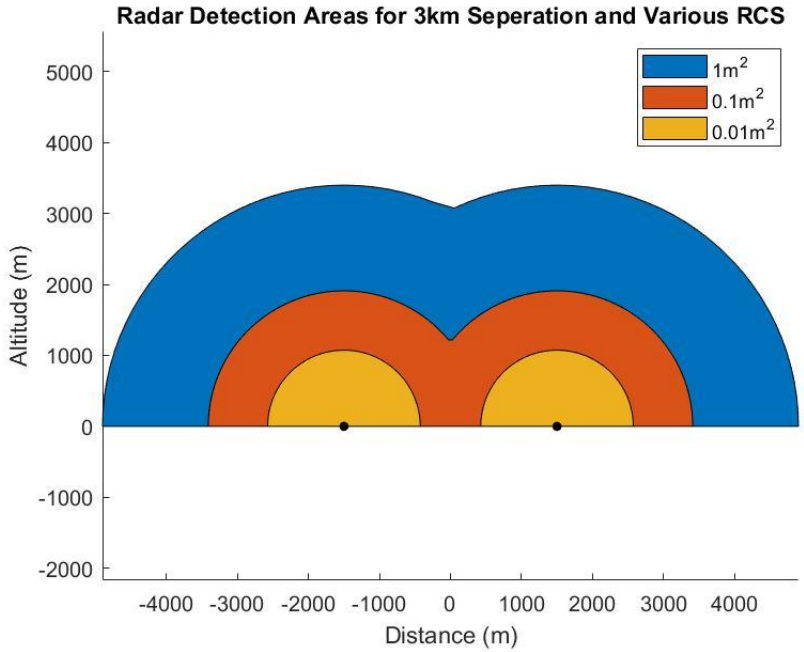
Elevation Plane ($\theta = 90°$)

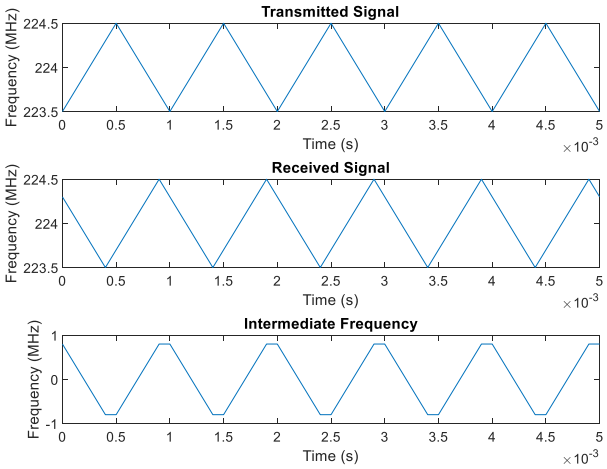


Simulation Summary	
Peak Gain	6.03 dB
Peak Realized Gain	6.00 dB
S11	-22.8 dB
RF Circuit Noise Figure	2.309 dB

Radar Analysis

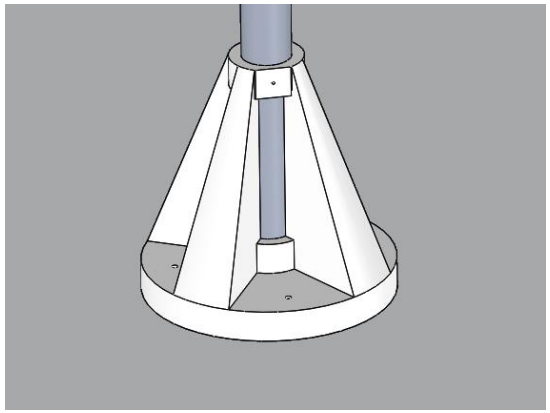
- Triangular Waveform

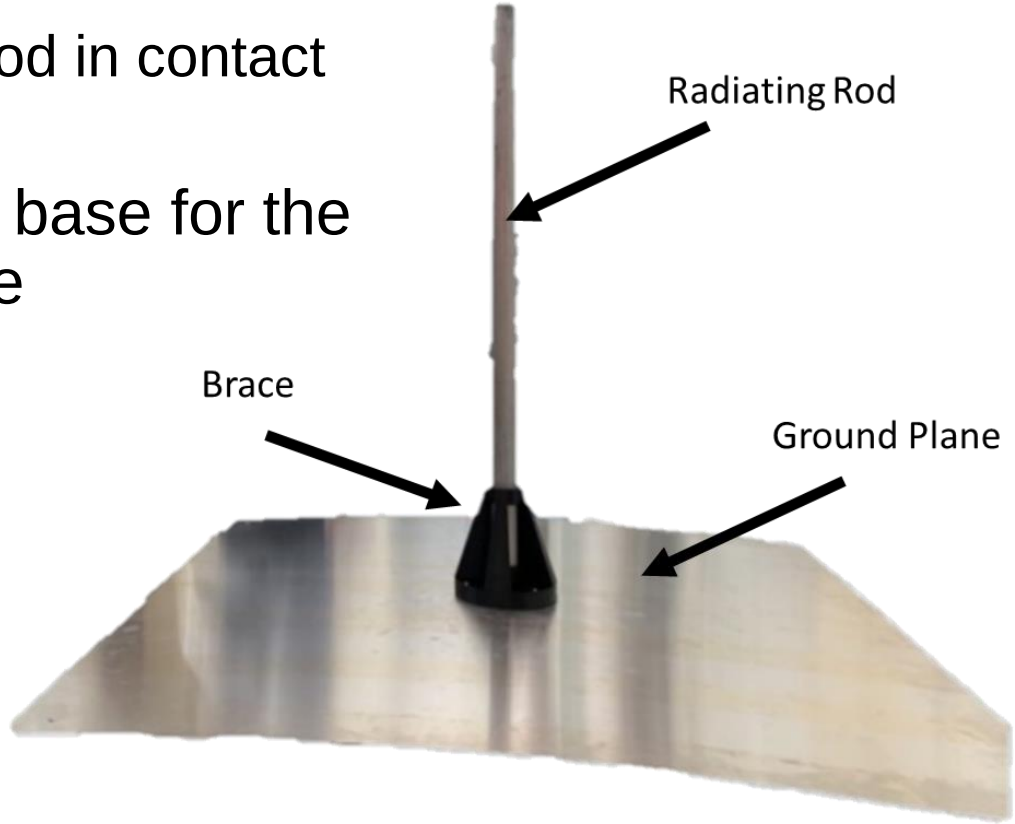




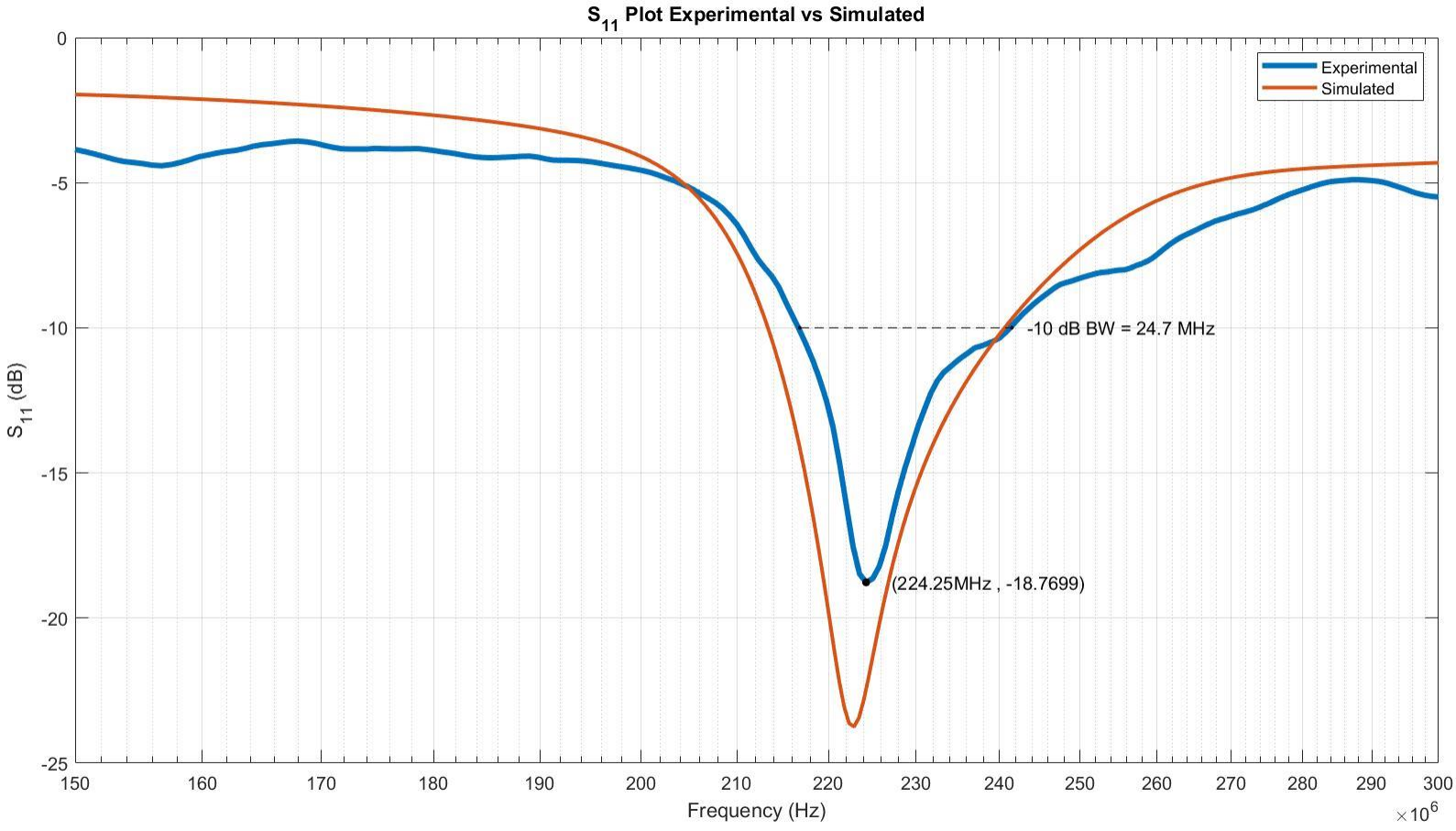
Prototyping

- 3D printed brace to hold the radiating rod straight
  - Keeps the radiating rod in contact with the SO-239
- Polycarbonate support base for the aluminum ground plane

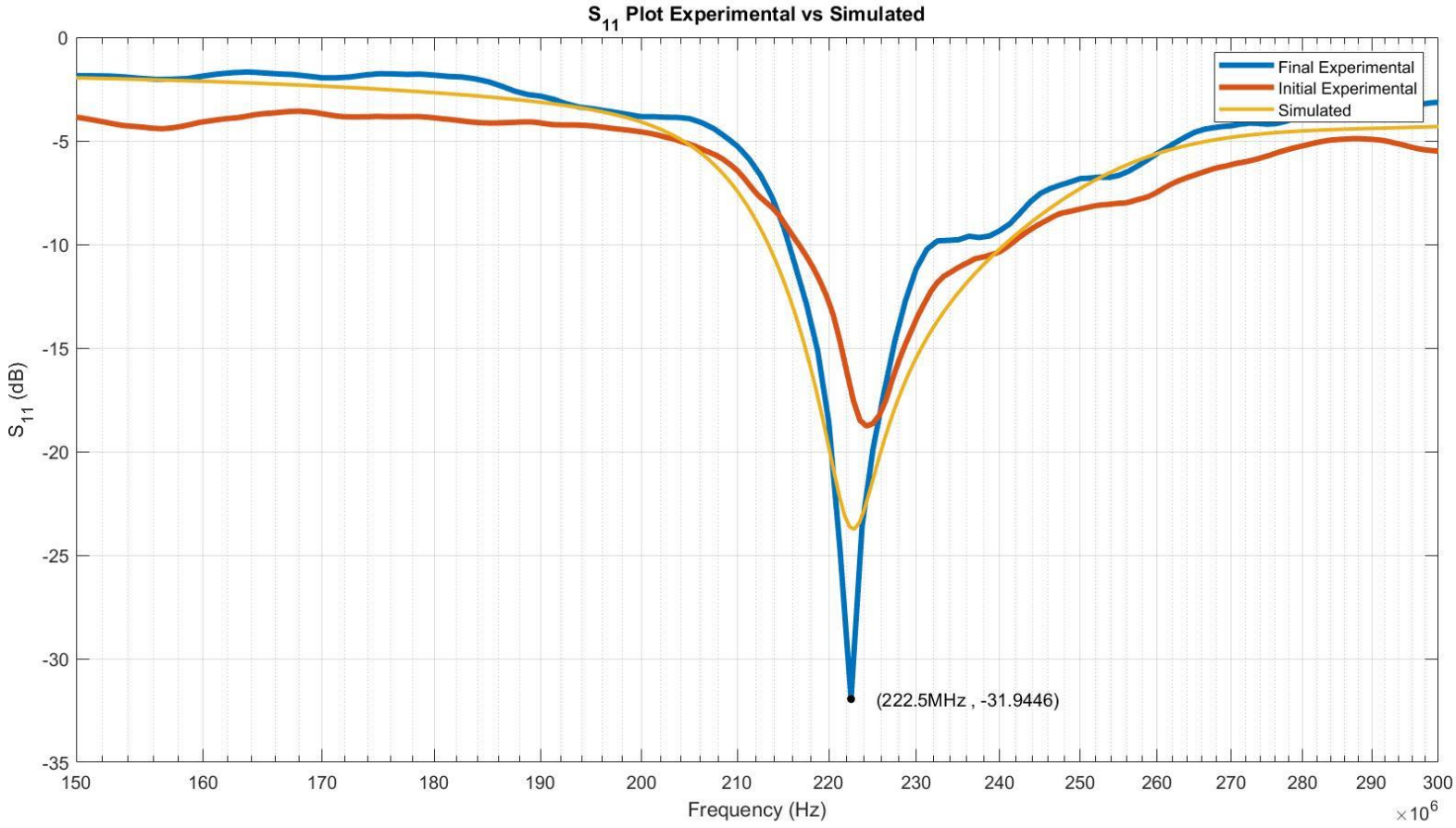




Prototyping – Cont'd

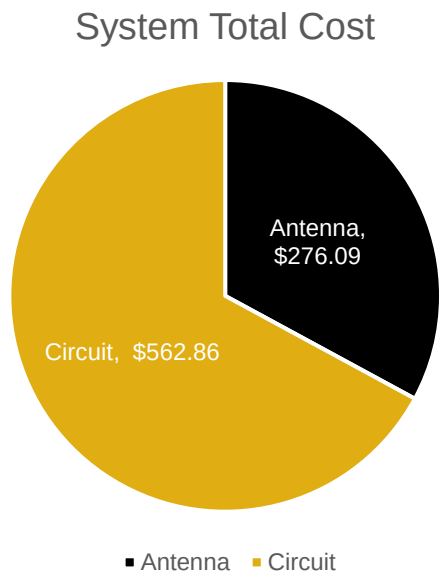


Prototyping – Cont'd



Cost Breakdown

- Total Cost Per Unit: $839
  - Antenna: $276
  - RF Circuit: $563



Part	Price
Aluminum-6061 Rod	$ 39.10
Aluminum-6061 Base Plate	$ 80.96
Polycarbonate Base Plate	$145.88
SO-239	$ 2.98
PLA Brace	$ 3.23
Machine Screws and Nuts	$ 3.94
Antenna Subtotal	$276.09
LNA	$ 8.76
Mixer	$ 72.70
Power Splitter	$ 6.23
Circulator	$455.00
Bandpass Filter	$ 20.17
Circuit Subtotal	$562.86
Grand Total	$838.95

Challenges

- Connection between SO-239 and Monopole Rod
- Effects of Brace on Return Loss (S_{11})
- Inability to Thoroughly Test Antenna Parameters

Future Work

- Anechoic Chamber Testing
  - Measurements of Gain and Radiation Pattern
- Construct and Test RF Circuit
- Testing Durability

Questions?