Differential and Single Ended Elliptical Antennas for 3.1-10.6 GHz Ultra Wideband Communication

Johnna Powell

Anantha Chandrakasan

Massachusetts Institute of Technology

Microsystems Technology Laboratory (MTL)

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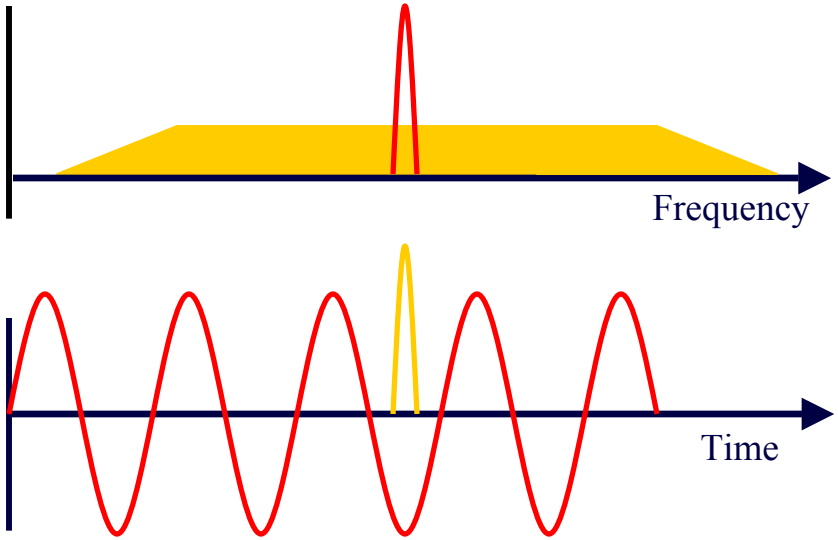
Outline and Goals

- Introduction
- Specifications and Considerations
- Discrete System Implementation
- Antenna Designs
- Antenna Results
  - Frequency
  - Time Domain
  - Anechoic Chamber

Introduction

- Motivation for UWB?
  - Revolutionary approach to wireless communication
  - Pulse based waveforms compressed in time
  - 3.1-10.6 GHz, -41.3 dBm/MHz
  - Low power levels allow for coexistence



UWB Impact on Antenna Design

Impedance Matching Requirements

- Bandwidth +100% of f_c
  - $|\Gamma| = |S_{11}| < 1/3$
  - VSWR < 2
  - $-10\log|S_{11}^2| =$ Return Loss > 10 dB

Power Loss < 10%

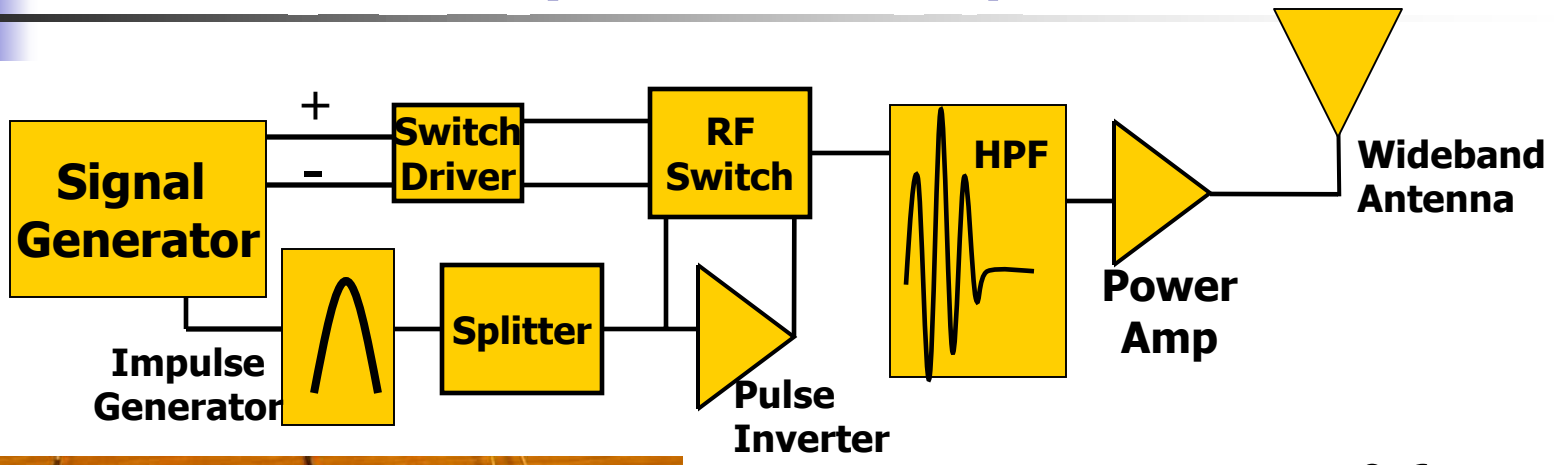
Wave Reception

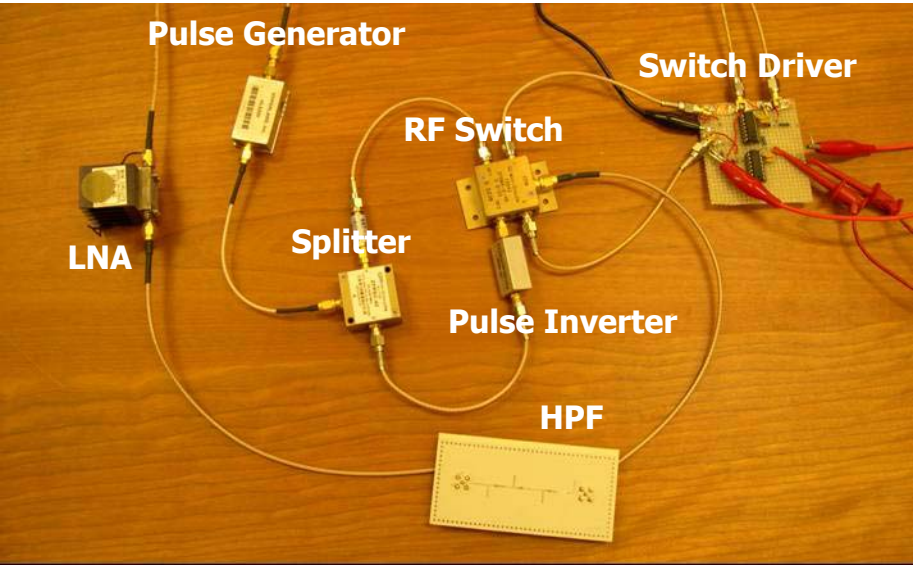
- Linear Phase
- High Radiation Efficiency
- Omnidirectional Radiation Pattern
- Time Domain Pulse Fidelity

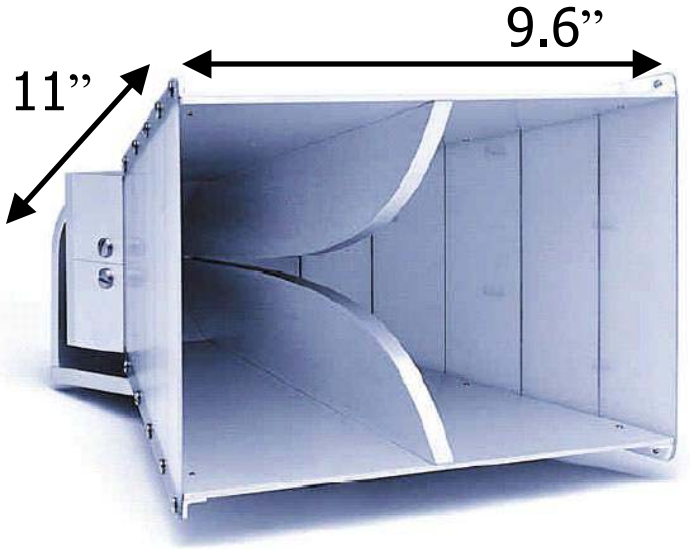
Physical Constraints

- Compatible with Portable Devices
- Small, Compact, Planar

Discrete System Implementation



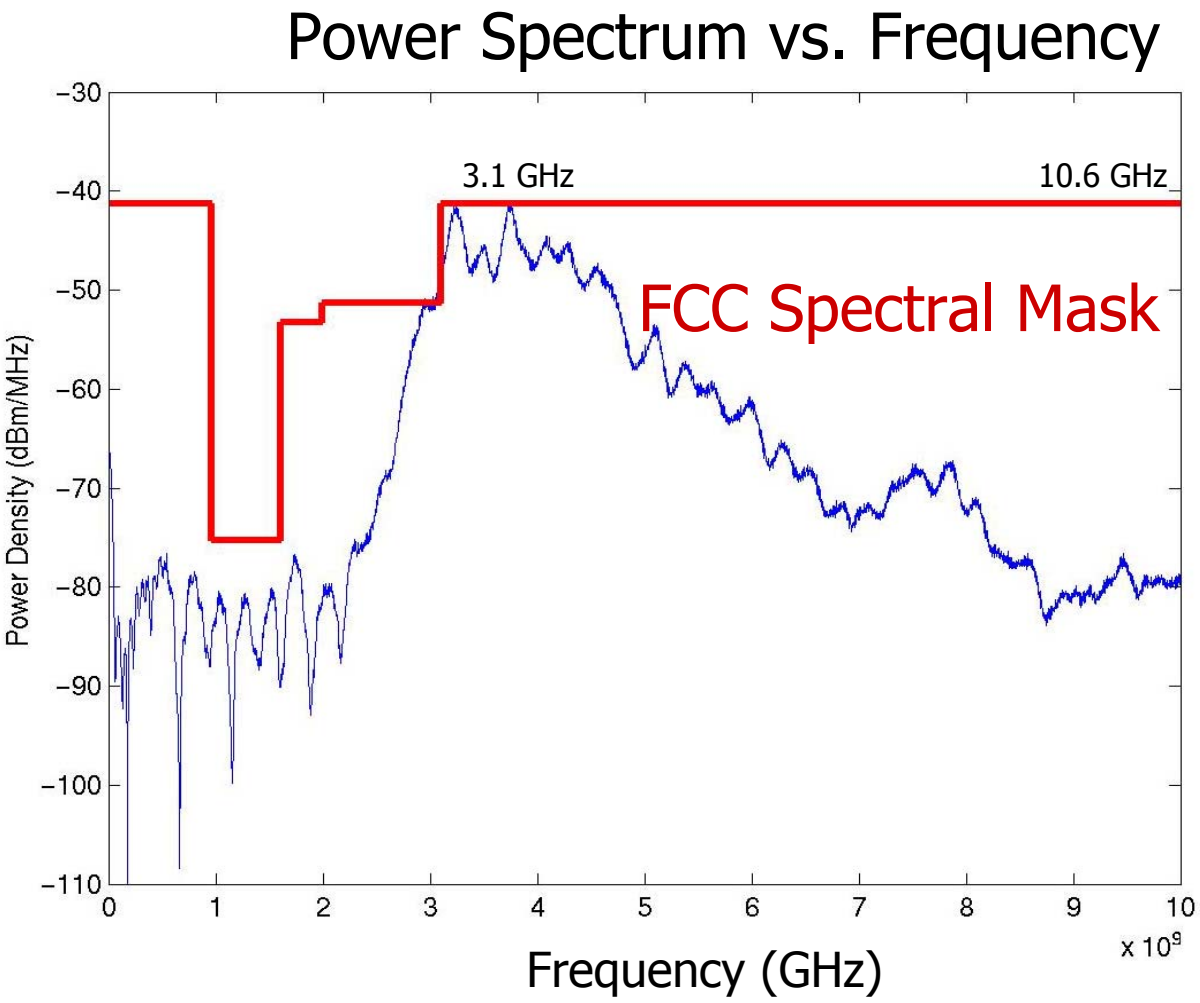




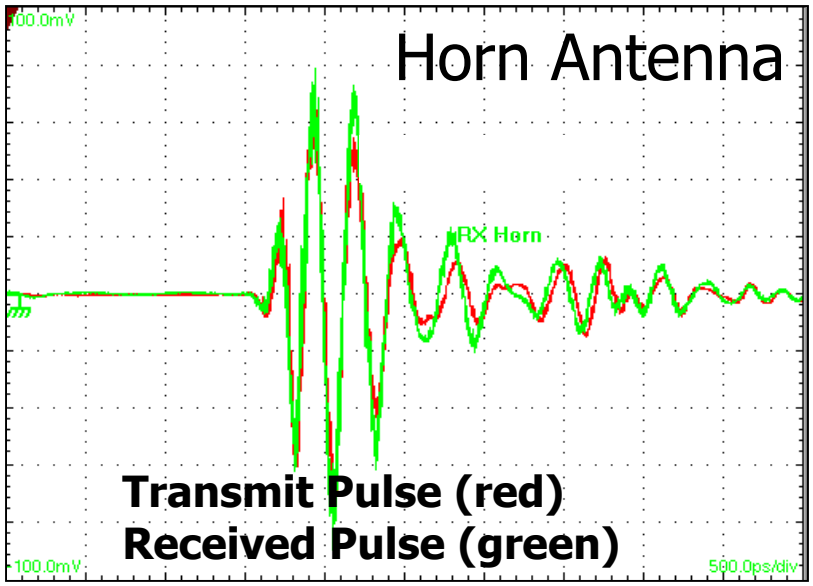
System Modeled after design by E. Green, Manny, B., “Ultra Wideband: A Disruptive RF Technology,” *Intel Developer Conference*, February 28, 2002.

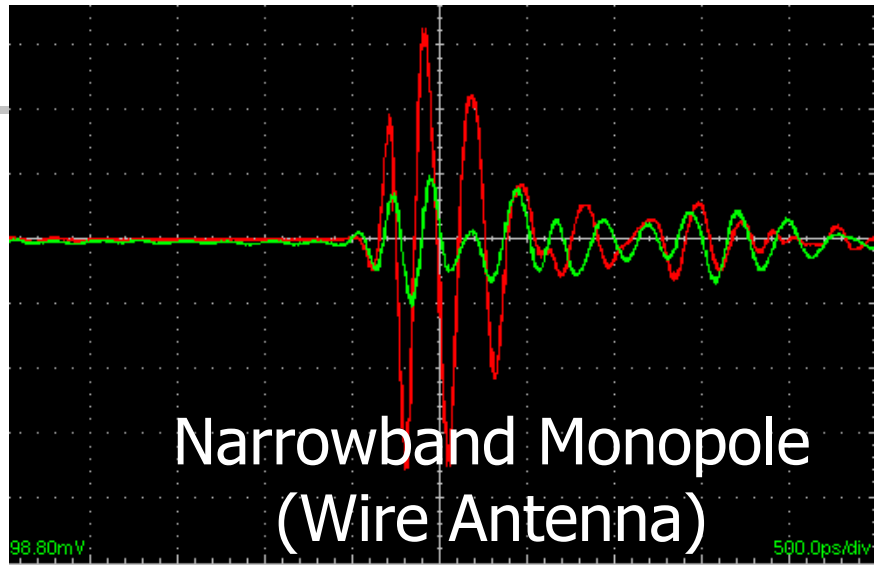
Discrete System Implementation

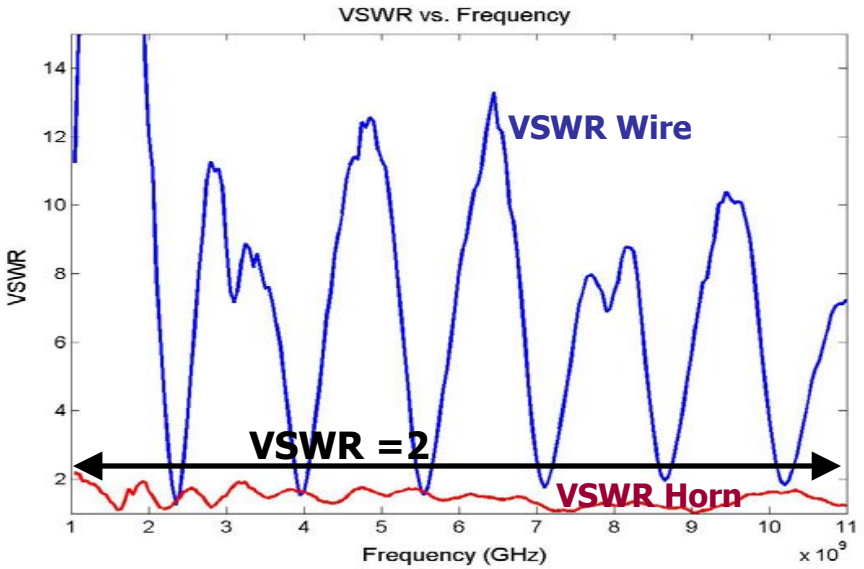
Transmit Pulse Power Density



Discrete System Implementation

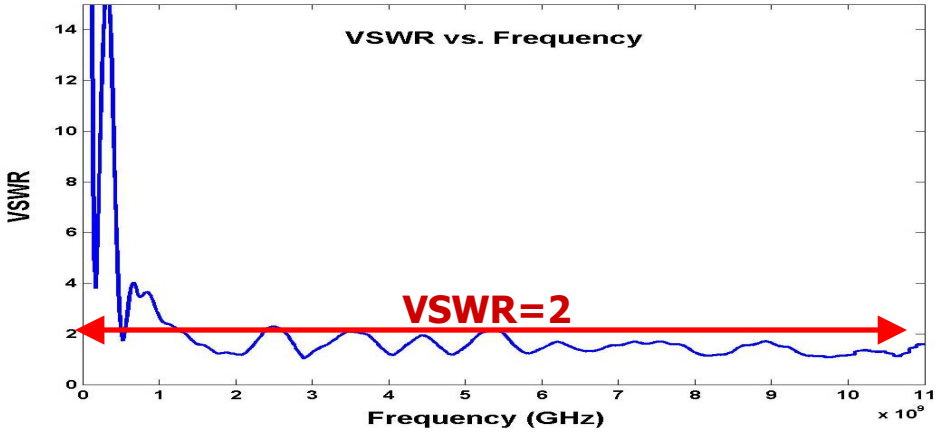


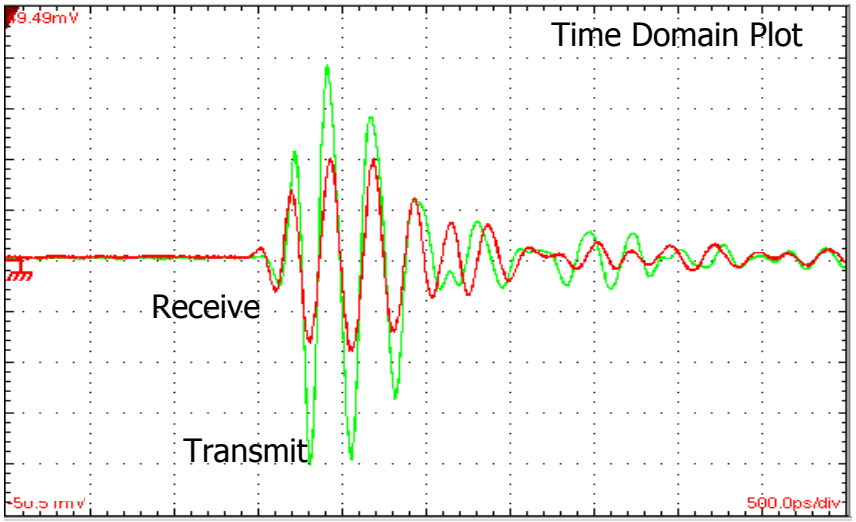




A wideband impedance match indicates optimal reception for a wideband pulse

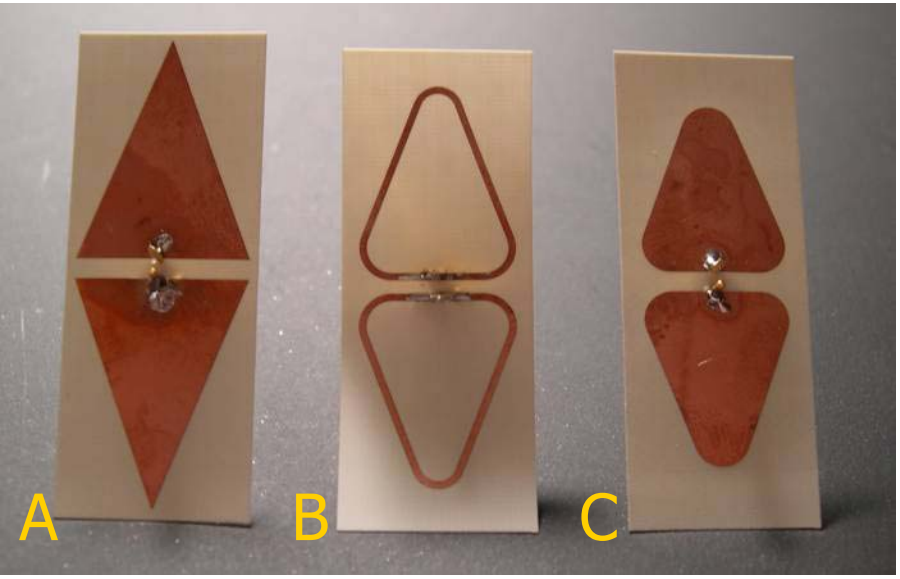
Spiral Equiangular Slot Patch



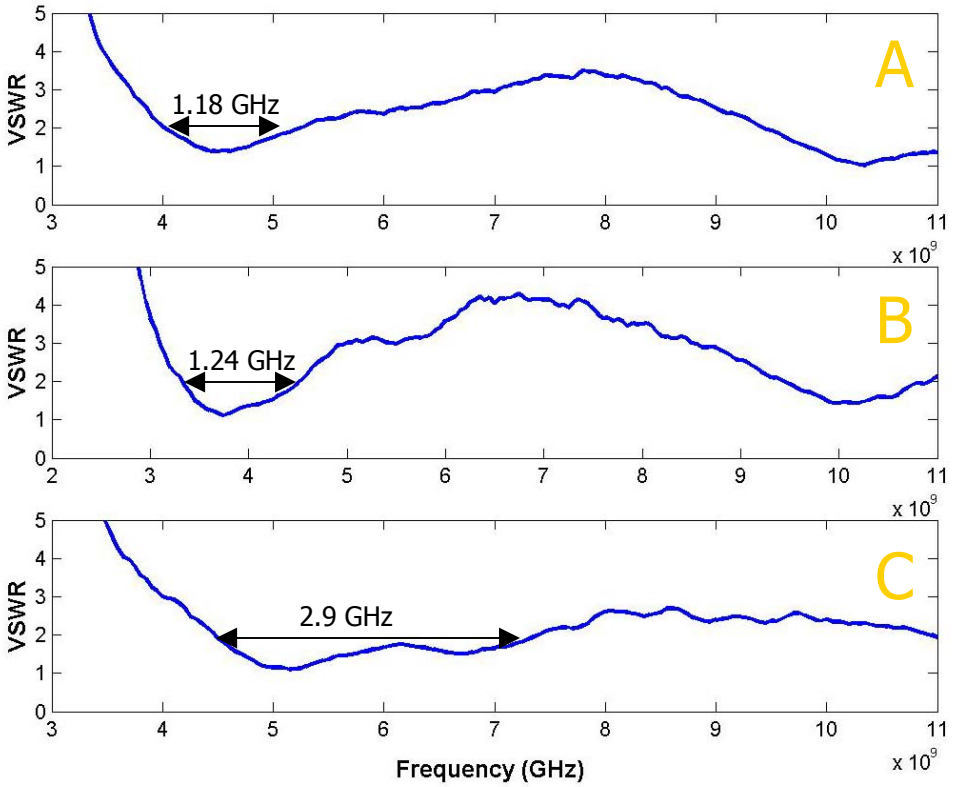


1. Johnna Powell, Anantha P. Chandrakasan, "Spiral Slot Patch Antenna and Circular Disc Monopole for 3.1-10.6 GHz Ultra Wideband Communication", *Int. Symp. Antennas and Propagation, August 2004*

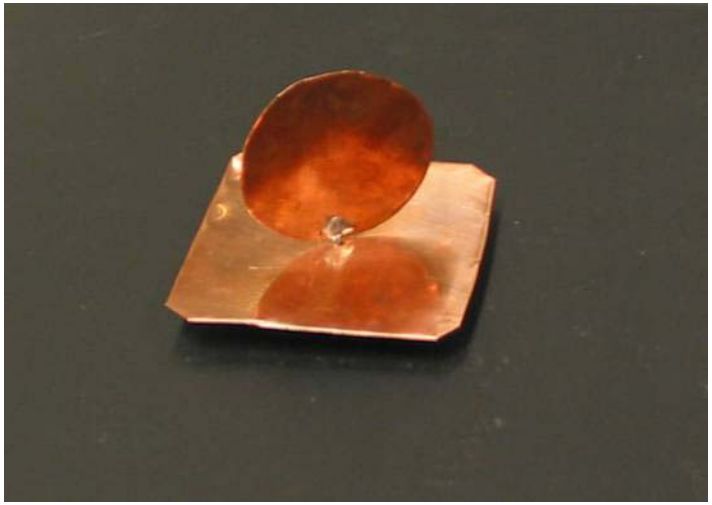
Diamond Dipole

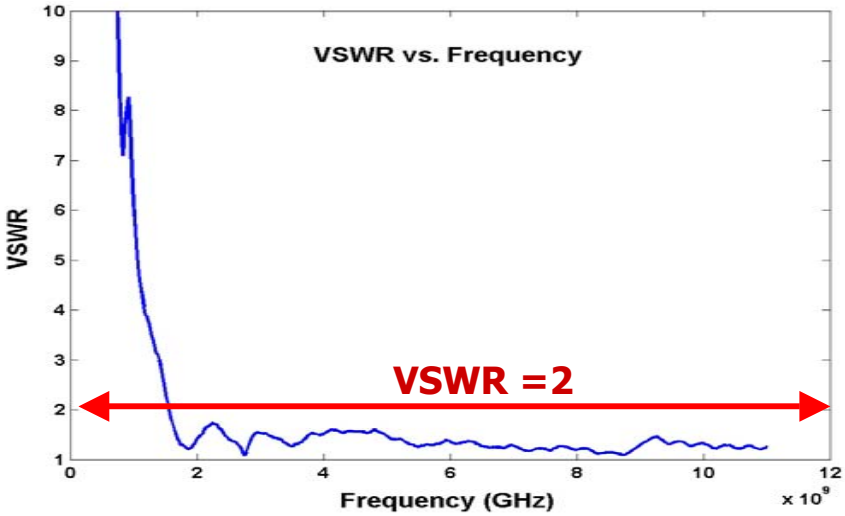


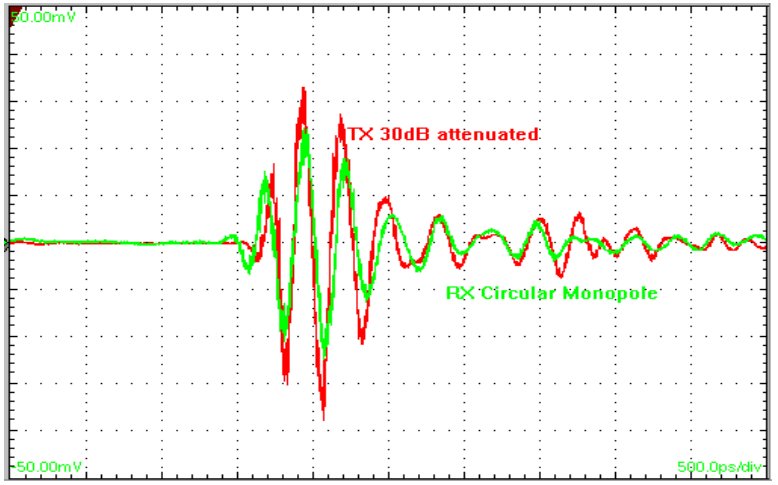
Time Domain Diamond Dipole



Circular Disc Monopole



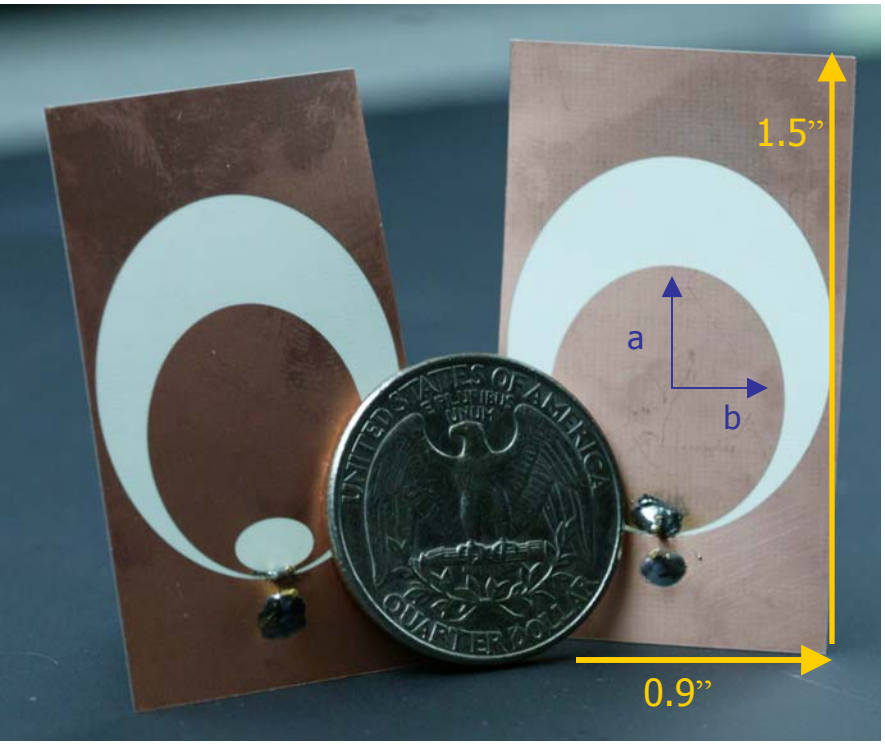


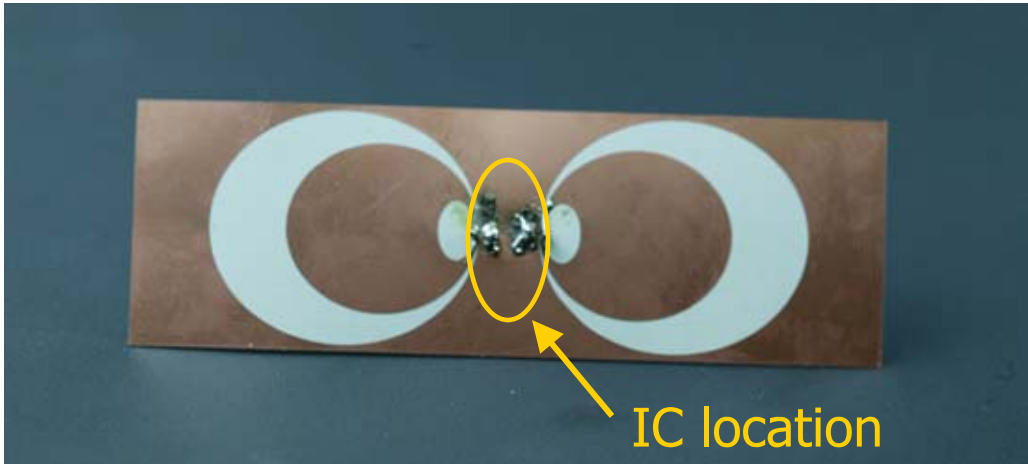


VSWR < 1.5 ➔ Power loss < 4%

Agrawall N. P. ,Kumar G.,Ray. K.P., "Wideband planar monopole antennas", IEEE Transactions on Antennas and Propagation

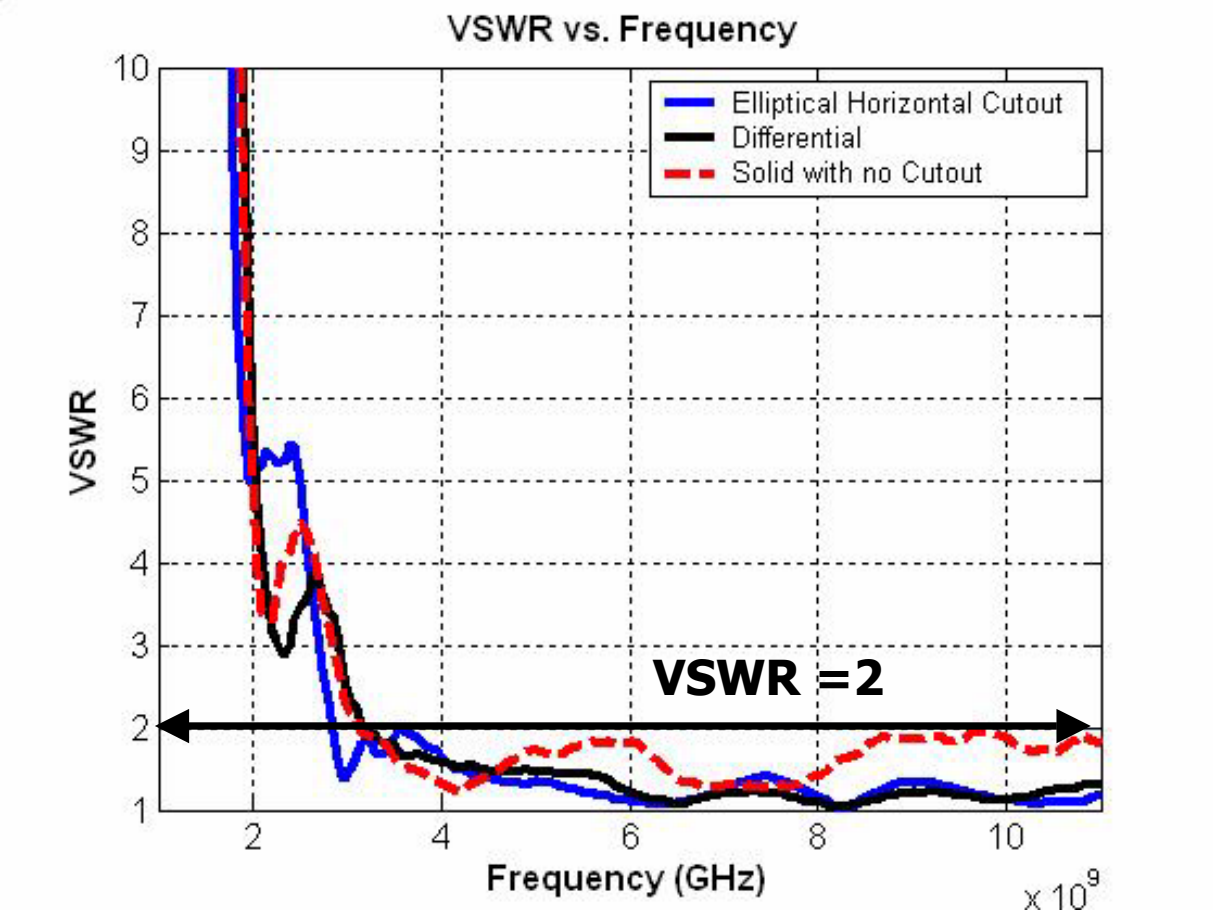
Single Ended and Differential Elliptical Antennas



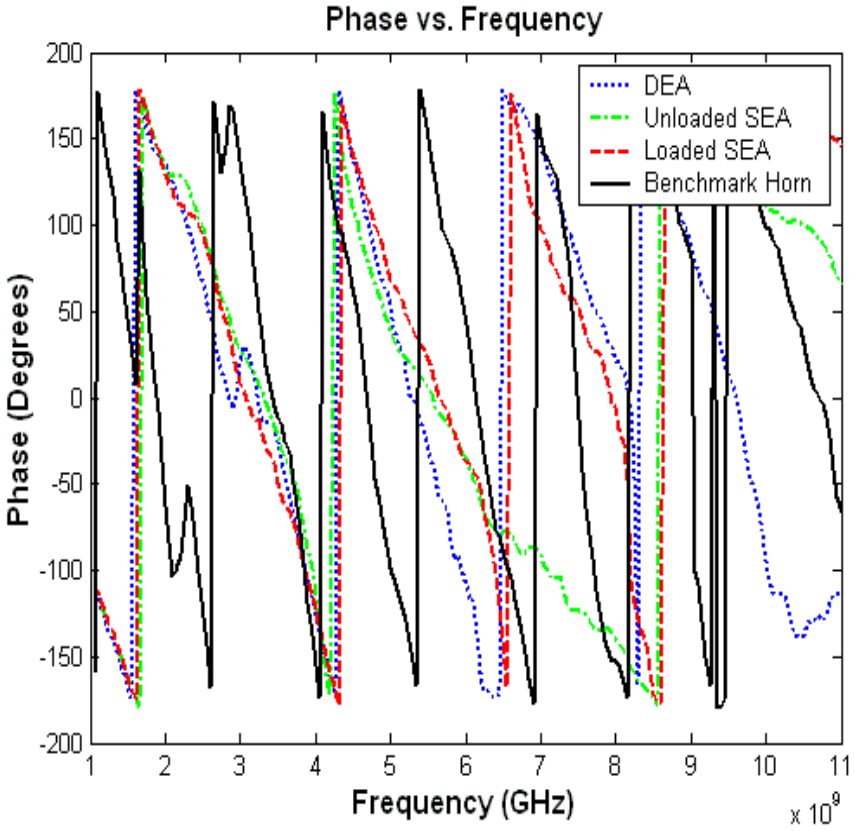


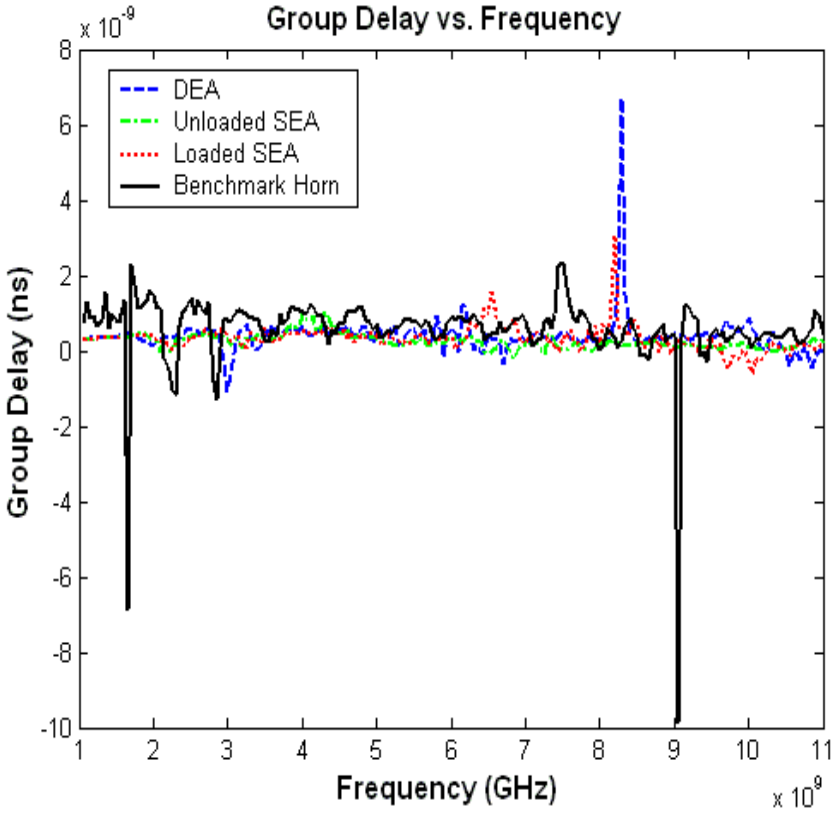
$$f_L = \frac{c}{\lambda} = \frac{30 * 0.24}{L + r} GHz$$

Antenna Results- Frequency



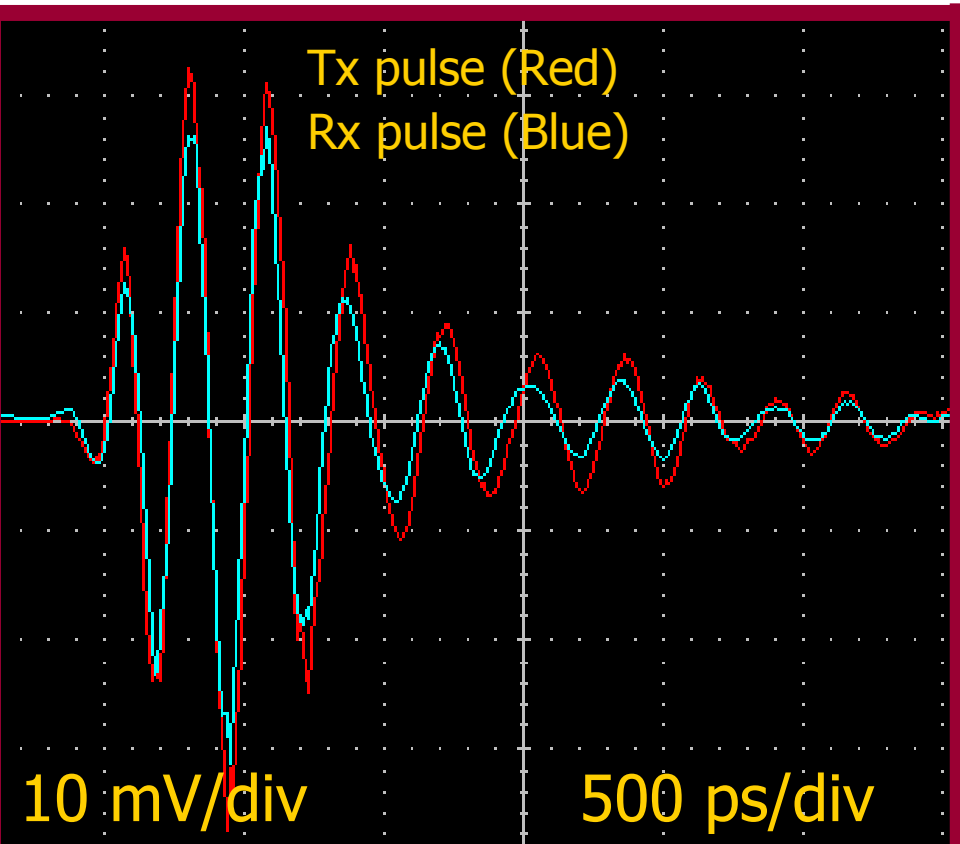
Phase and Group Delay Comparison



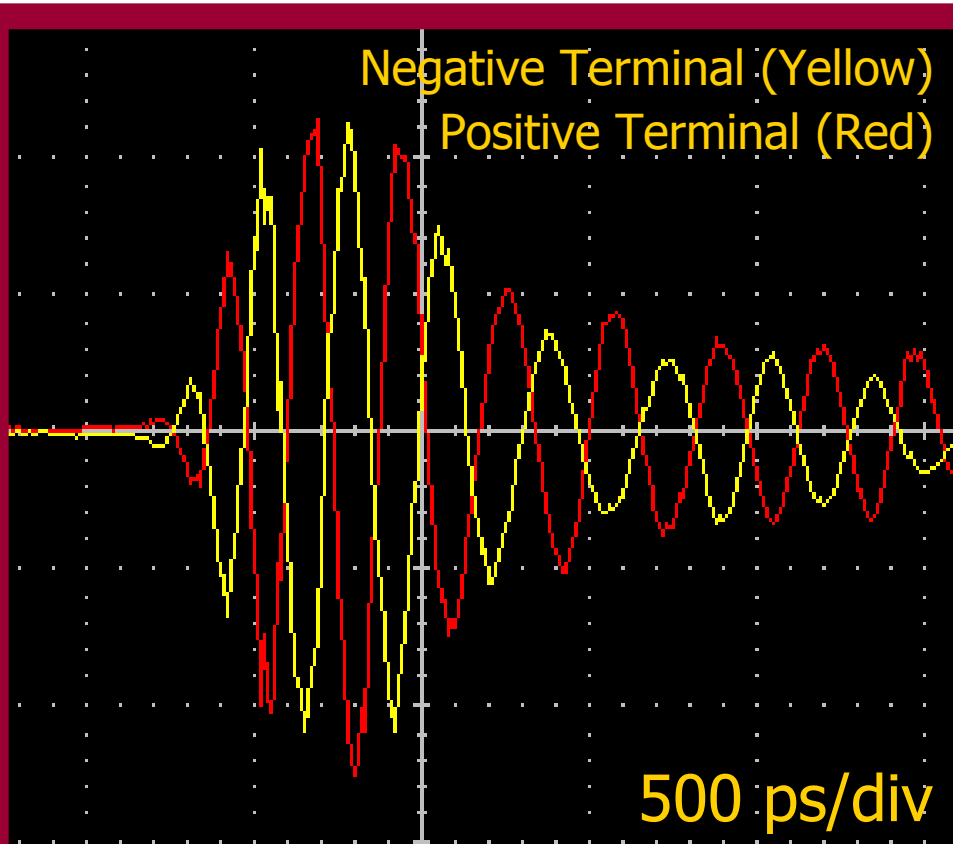


Antenna Results- Time Domain

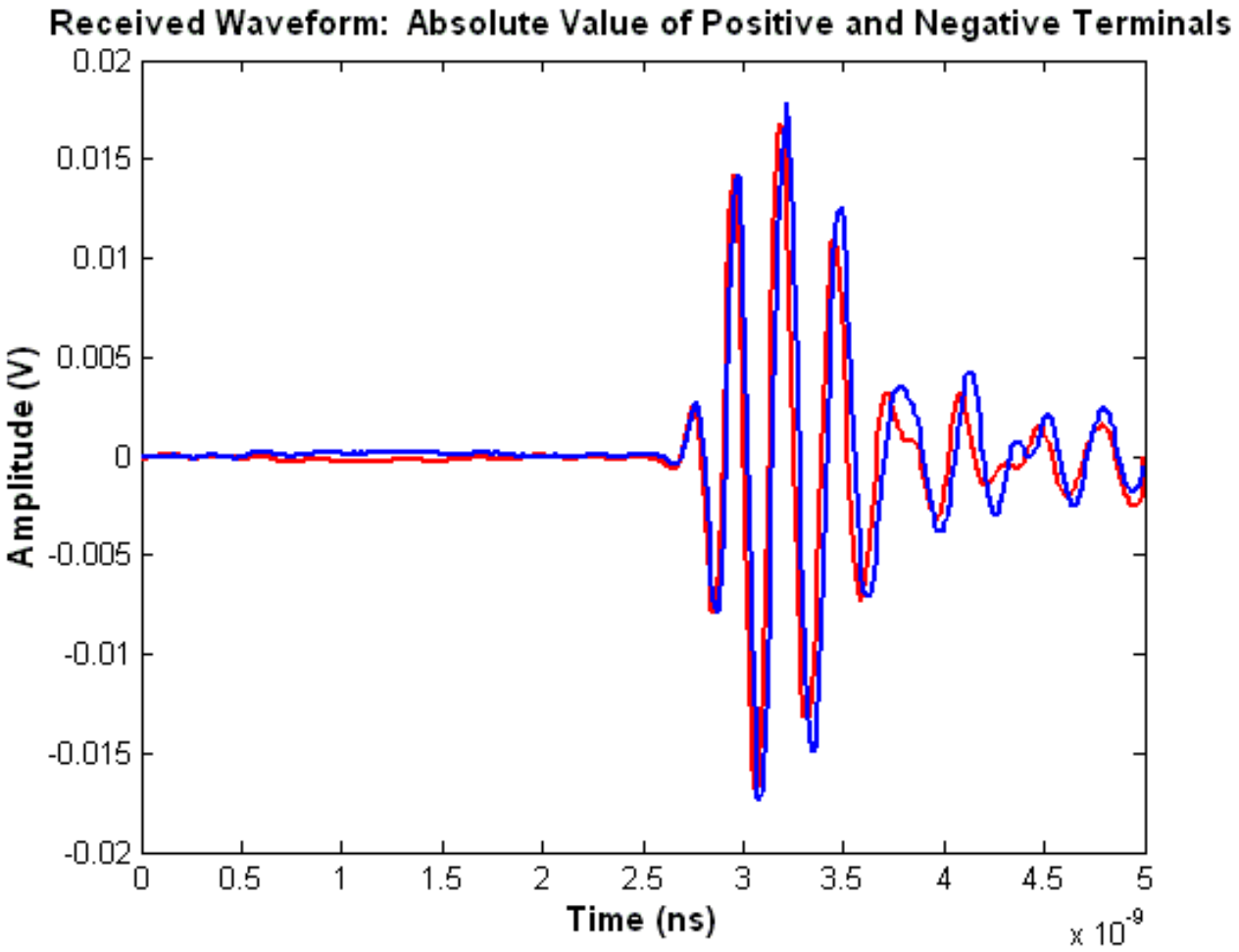
Single Ended Elliptical Antenna



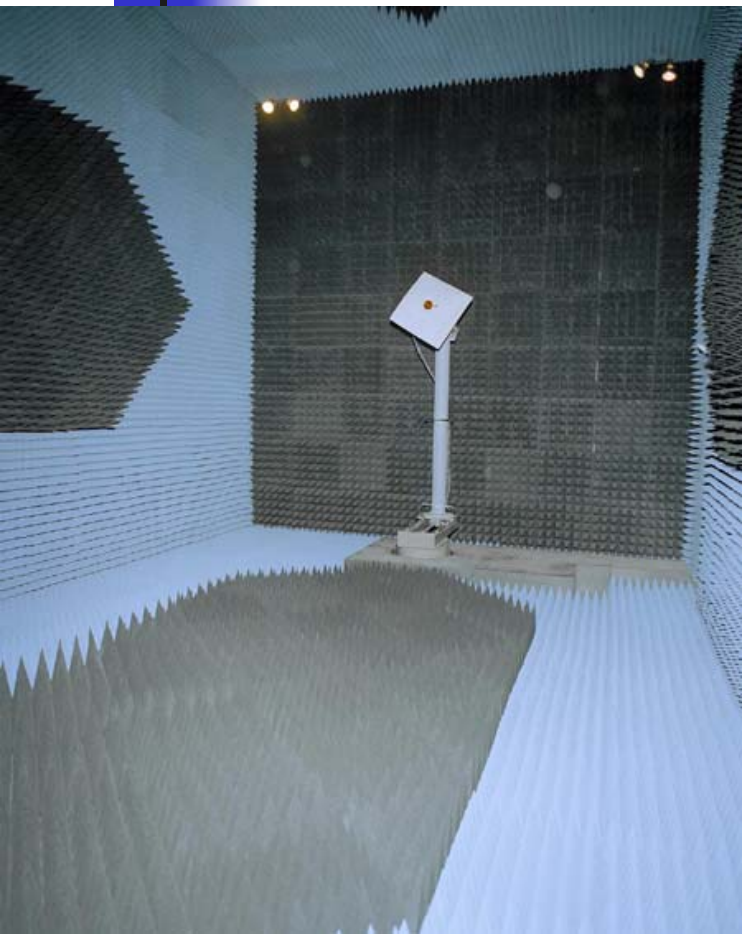
Differential Antenna

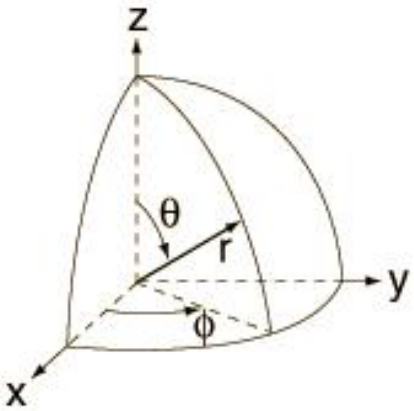


Absolute Value of Differential Pulses

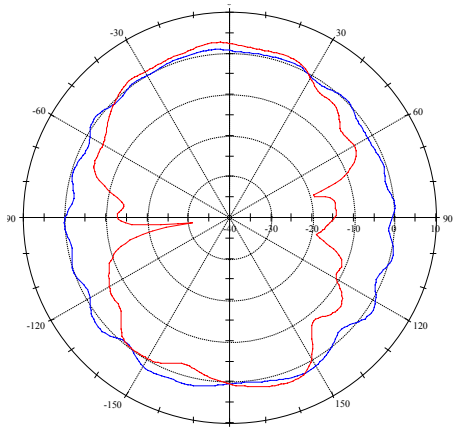


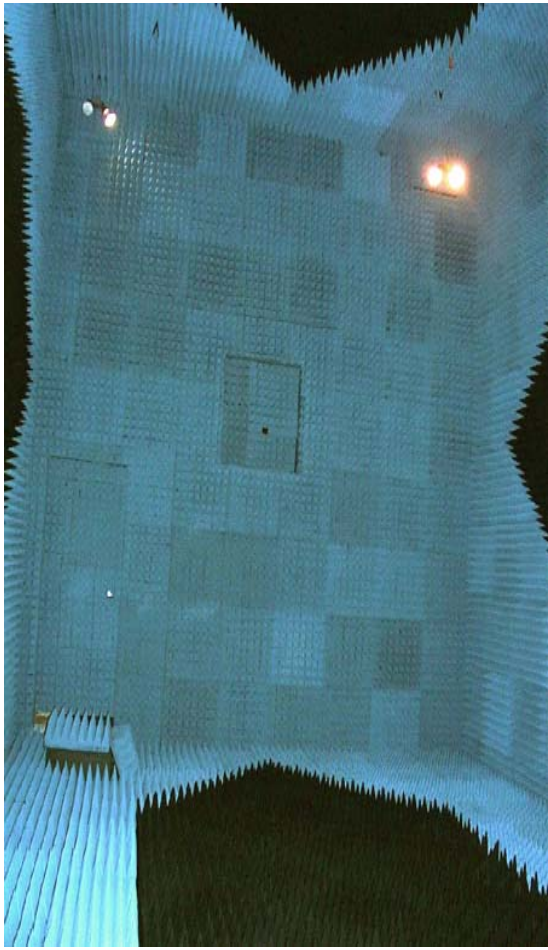
Antenna Results- Chamber





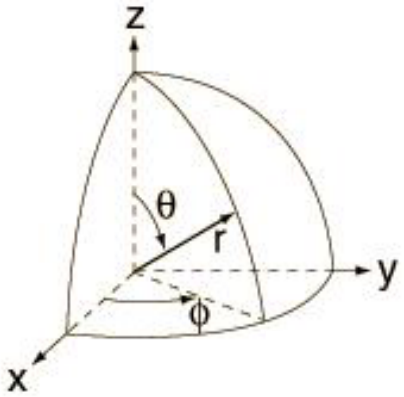
Spherical Coordinates:
Azimuth = Rotation in φ
Elevation = Rotation in θ





Photos courtesy Lincoln Labs

Antenna Results- Chamber



Spherical Coordinates:
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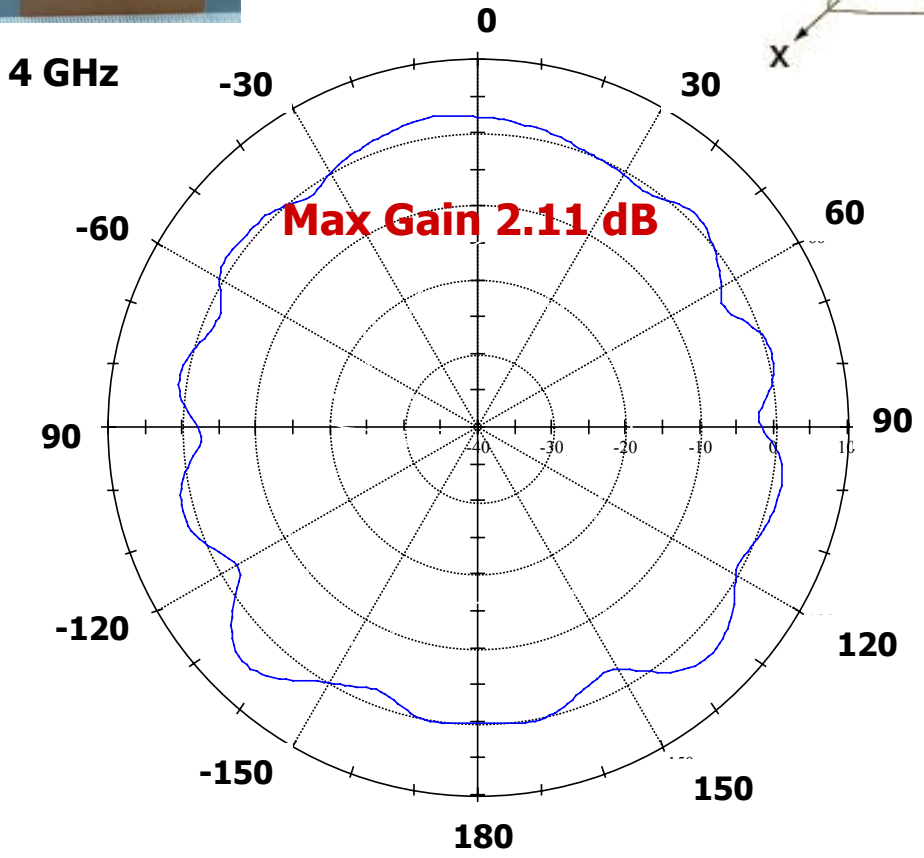
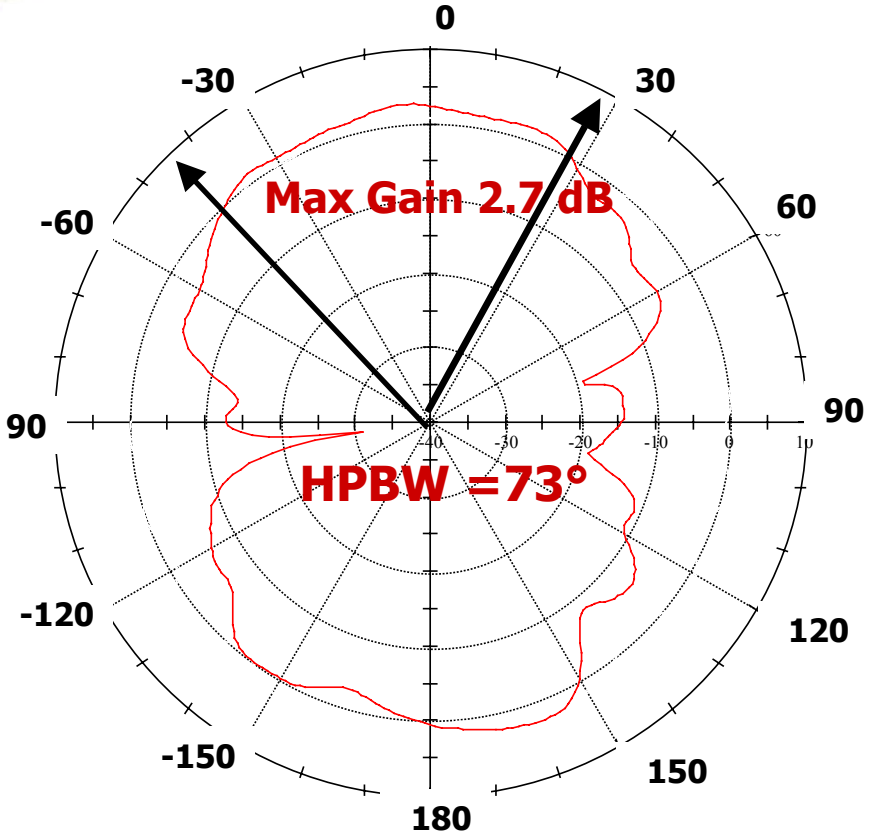
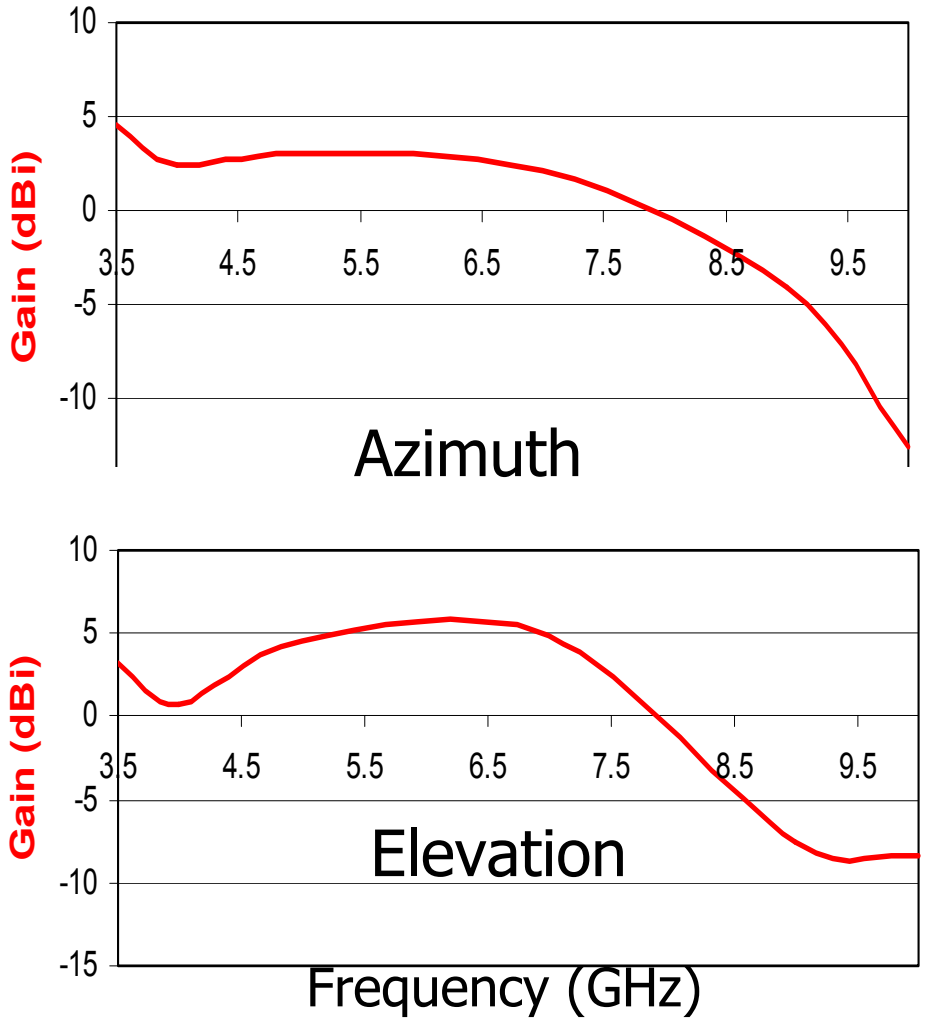




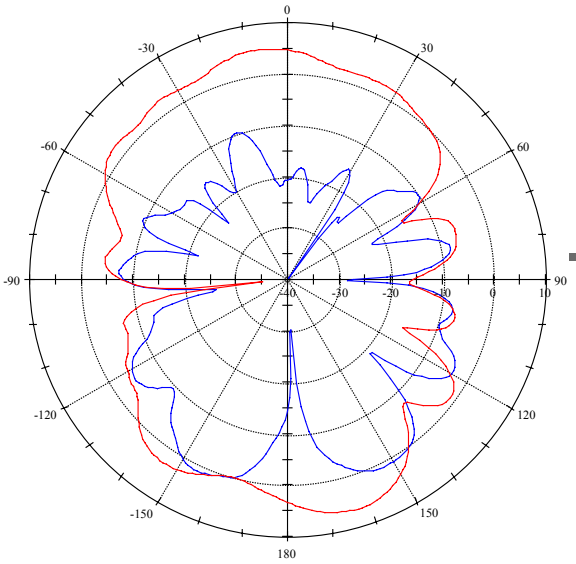
Lincoln Laboratory Measured Azimuth Pattern

Measured Elevation Pattern

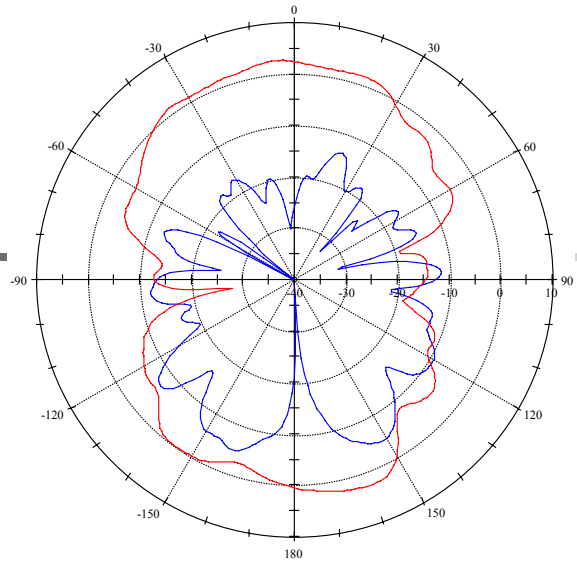
Gain vs. Frequency for Azimuth and Elevation Planes



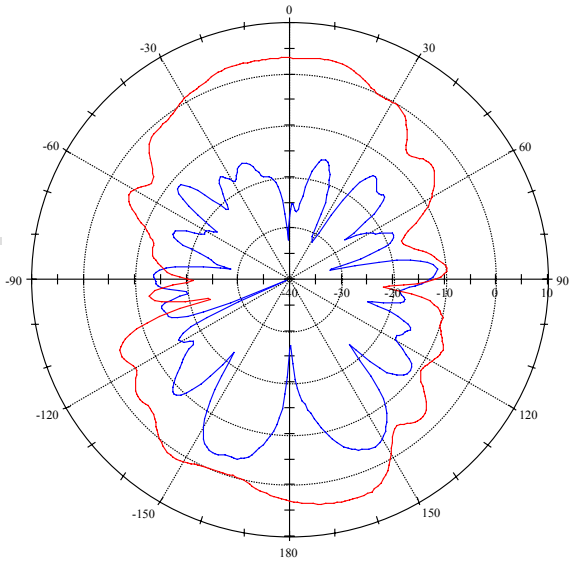
Radiation Patterns for Varying Frequency- Elevation Co-polarized



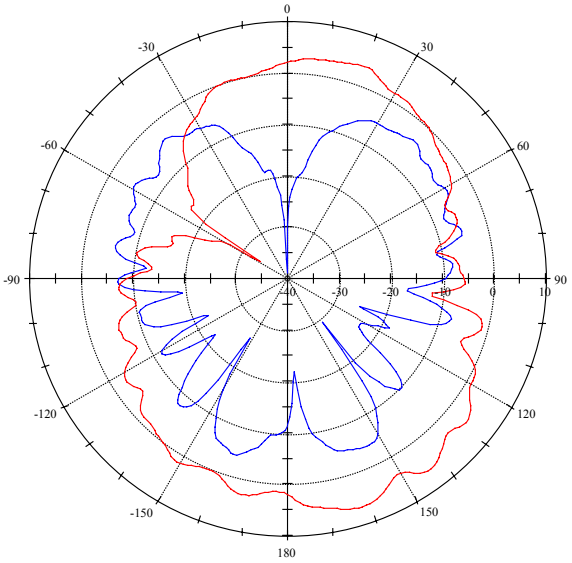
3.5 GHz



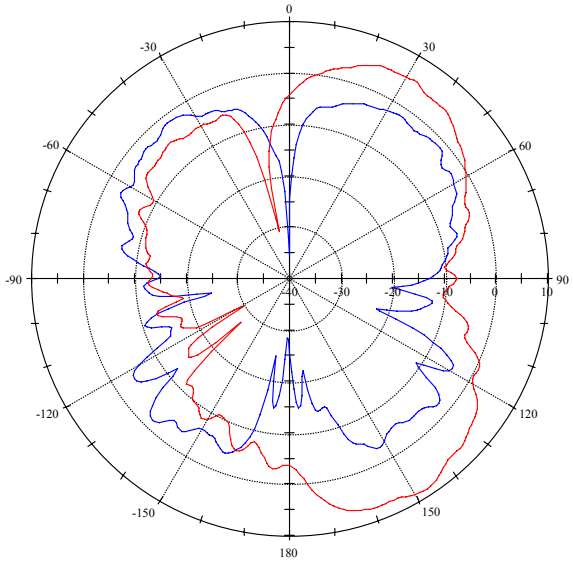
4 GHz



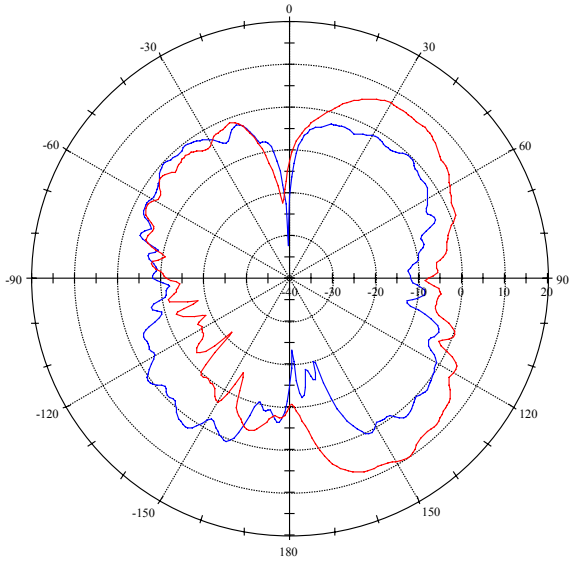
5 GHz



7 GHz

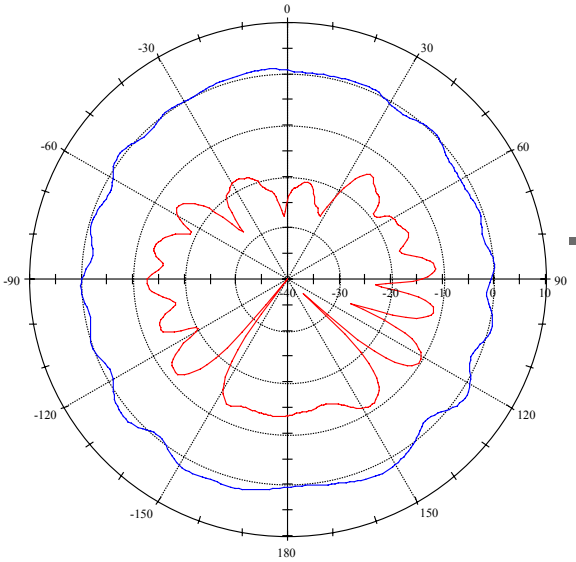


9 GHz

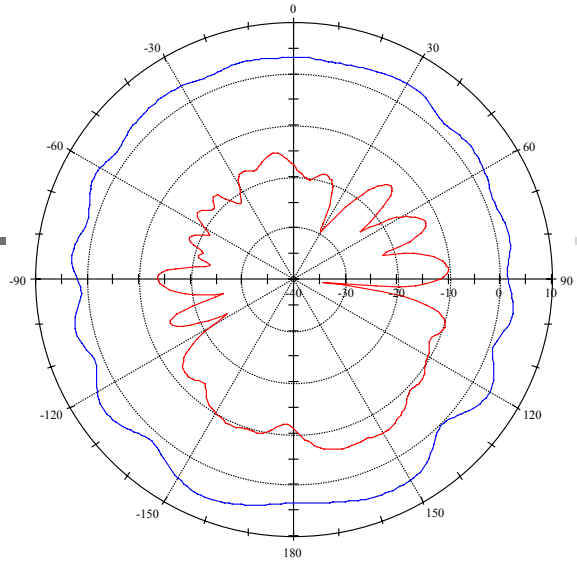


10 GHz

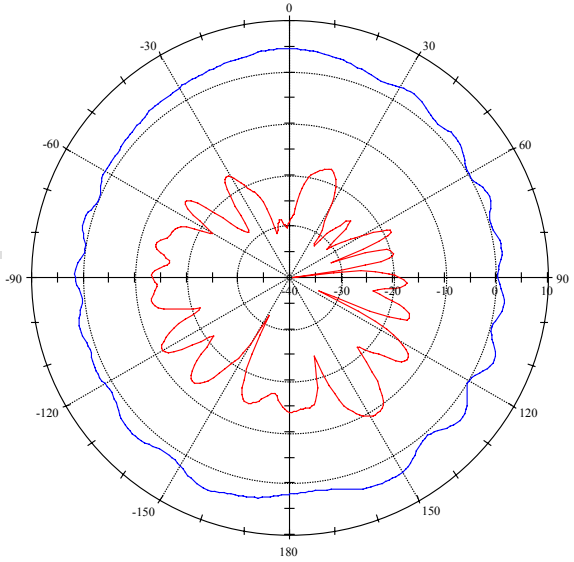
Radiation Patterns for Varying Frequency- Azimuth Co-Polarized



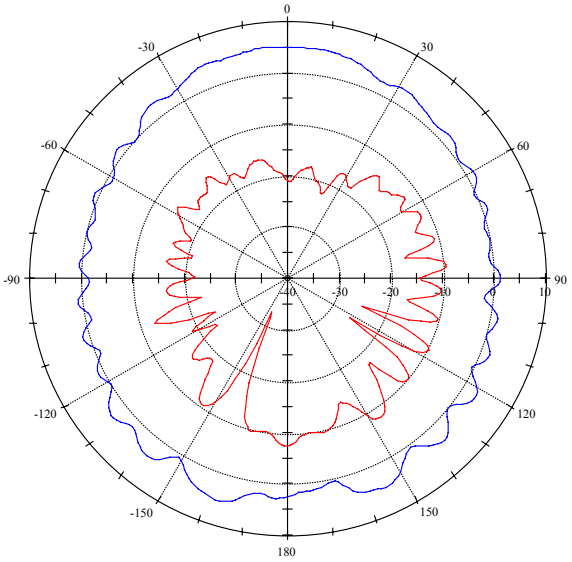
3.5 GHz



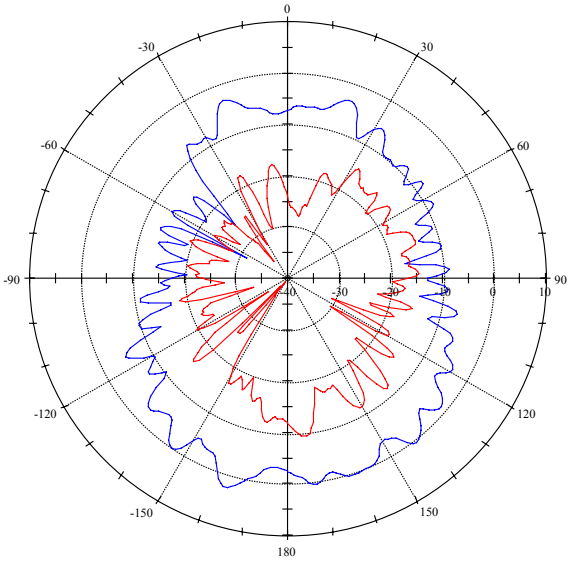
4 GHz



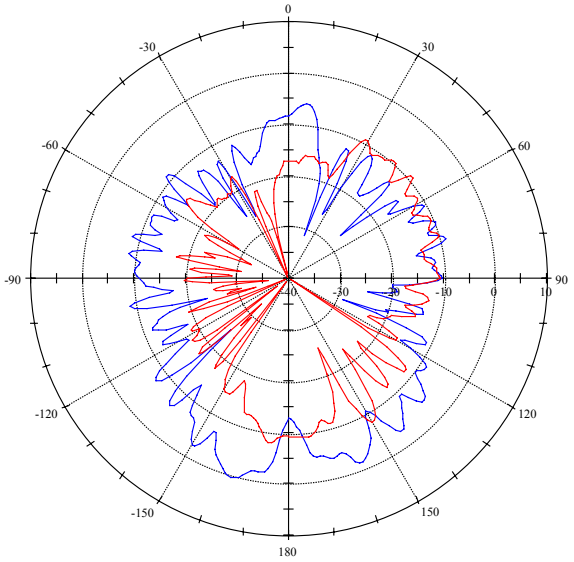
5 GHz



7 GHz

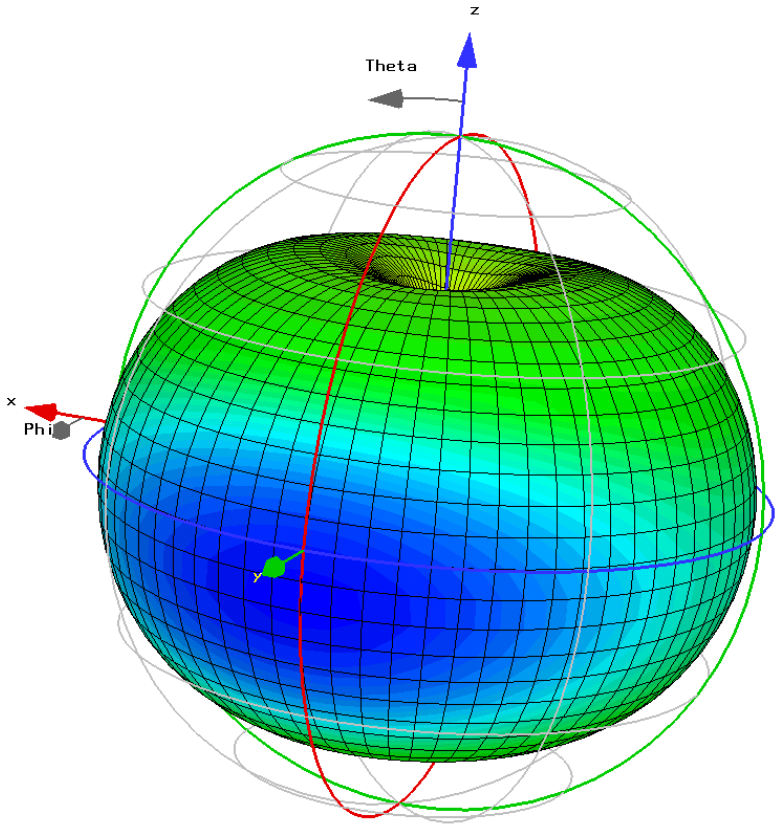


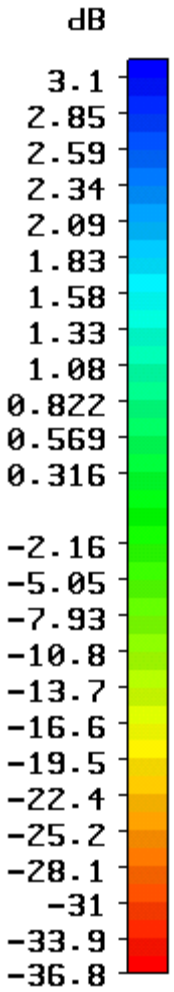
9 GHz



10 GHz

3-D Radiation Pattern





Farfield Simulated
Measurement
Frequency = 4 GHz
Radiation Efficiency = 99.58%
Total Efficiency = 92.90%
Gain = 3.22 dB

Measured
Frequency = 4 GHz
Radiation Efficiency = 93%
Impedance Efficiency = 99.3%
Total Efficiency = 92.3%
HPBW = 73°

Summary

- UWB Antenna Designs
  - VSWR < 2 for 3.1- 10.6 GHz
  - Near Omnidirectional Pattern
  - High Radiation Efficiency
  - Physically Small Size
- Discrete System Implementation
- Future Work: System Considerations