Spiral Slot Patch Antenna and Circular Disc Monopole Antenna for 3.1-10.6 GHz Ultra Wideband

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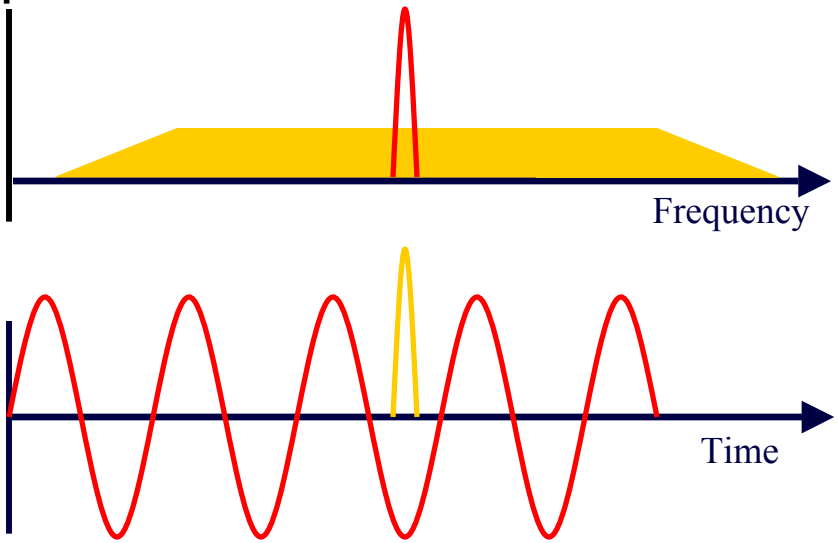
Outline and Goals

- 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%

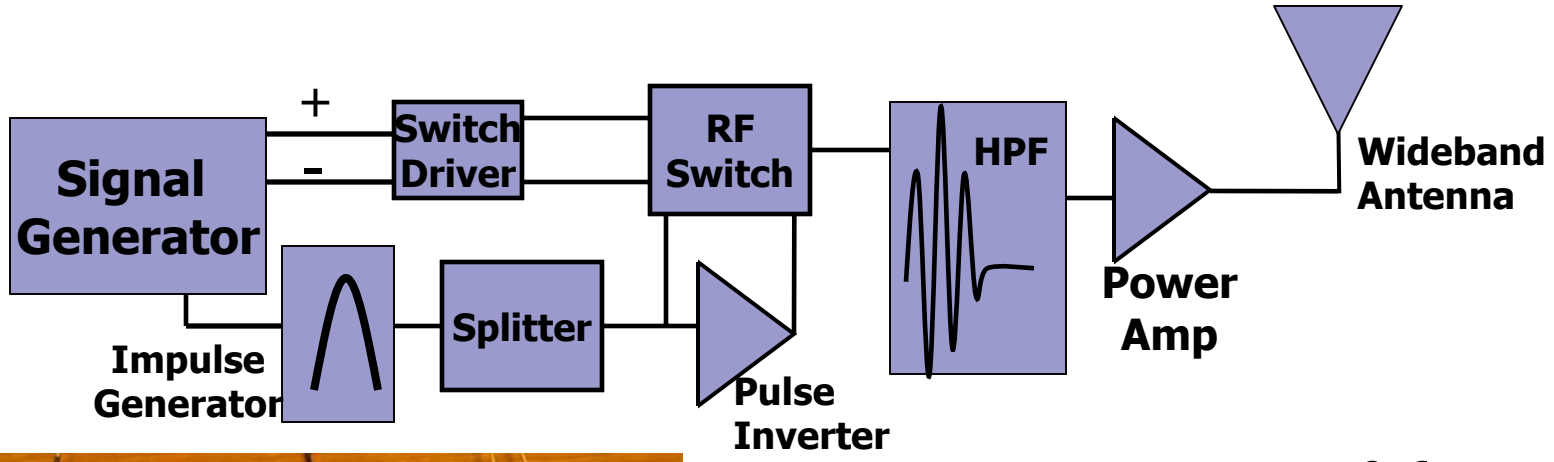
Wave Reception

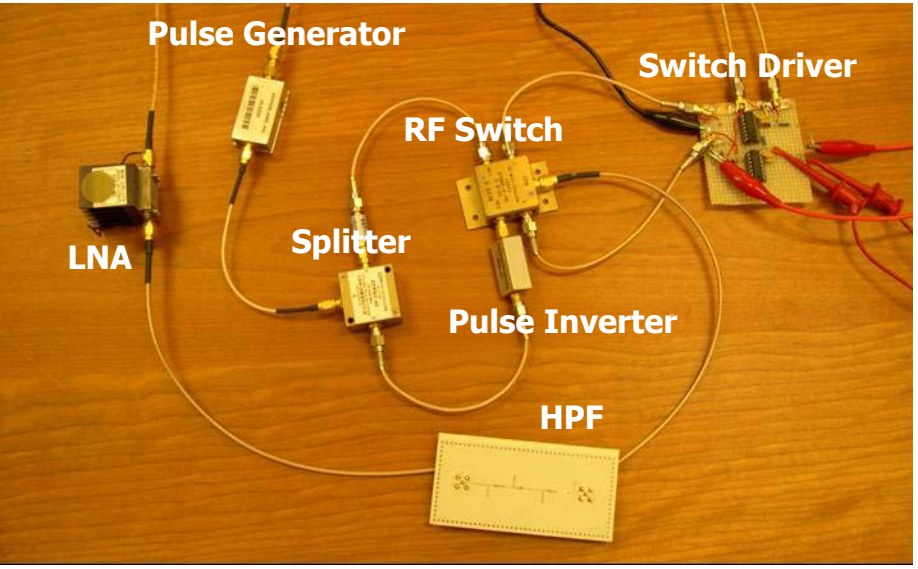
- Linear Phase
- High Radiation Efficiency
- Omnidirectional Radiation Pattern
- Time Domain Pulse Fidelity

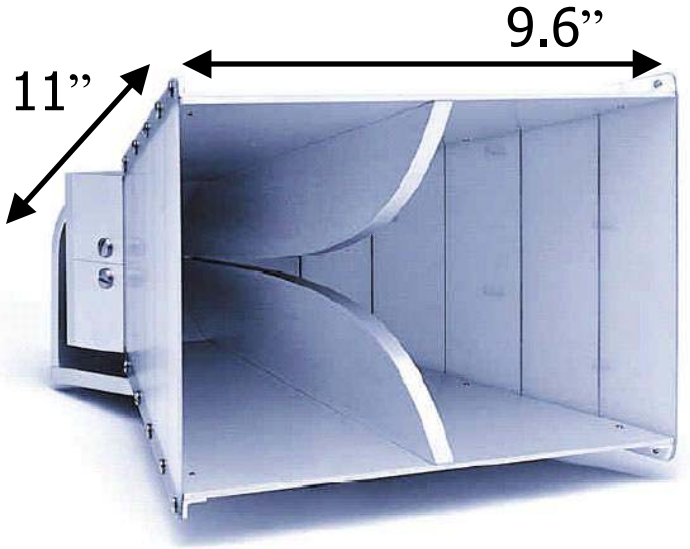
Physical Constraints

- Compatible with Portable Devices
- Small, Compact, Planar

Discrete System Implementation



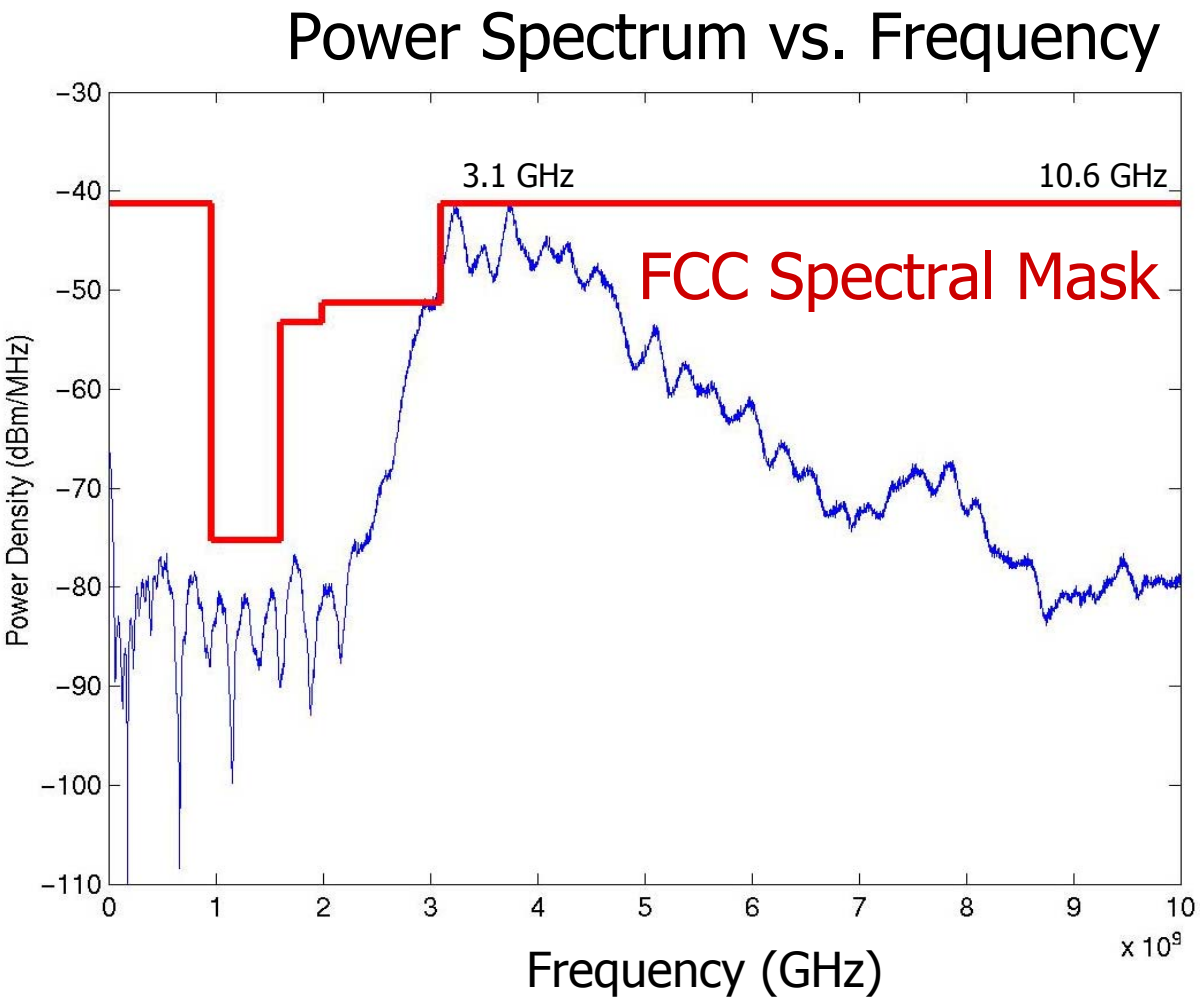




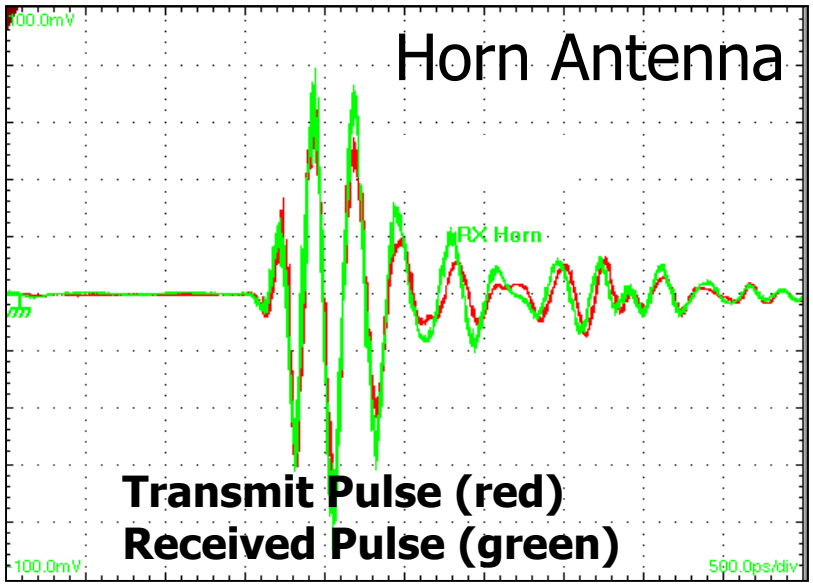
System Modeled after design by E. Green, Manny, B., “Ultra Wideband: A Disruptive RF Technology,” *Intel Developer Conference*, February 28, 2002.

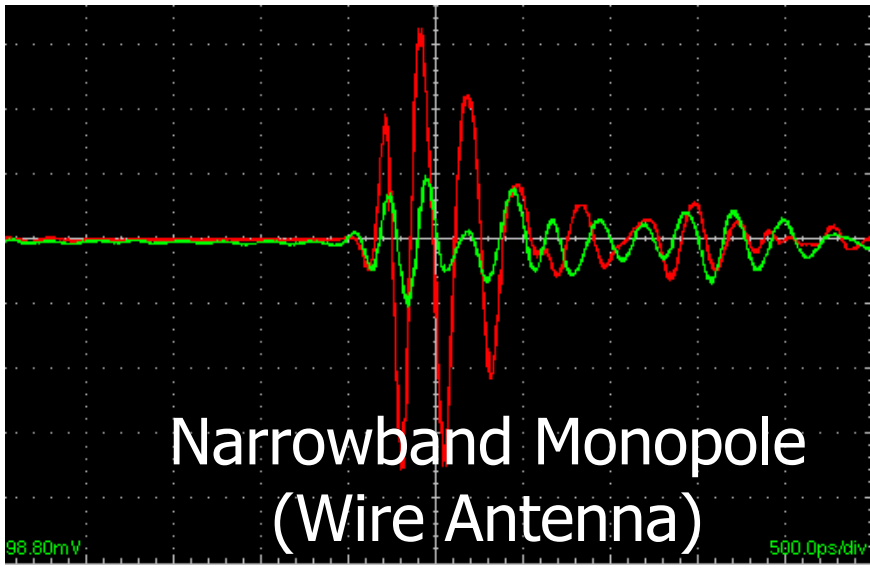
Discrete System Implementation

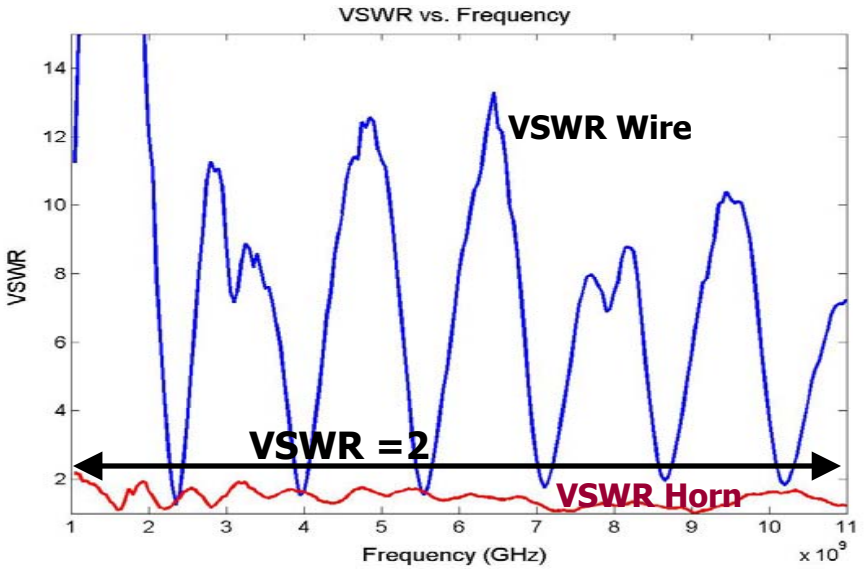
Transmit Pulse Power Density



Discrete System Implementation







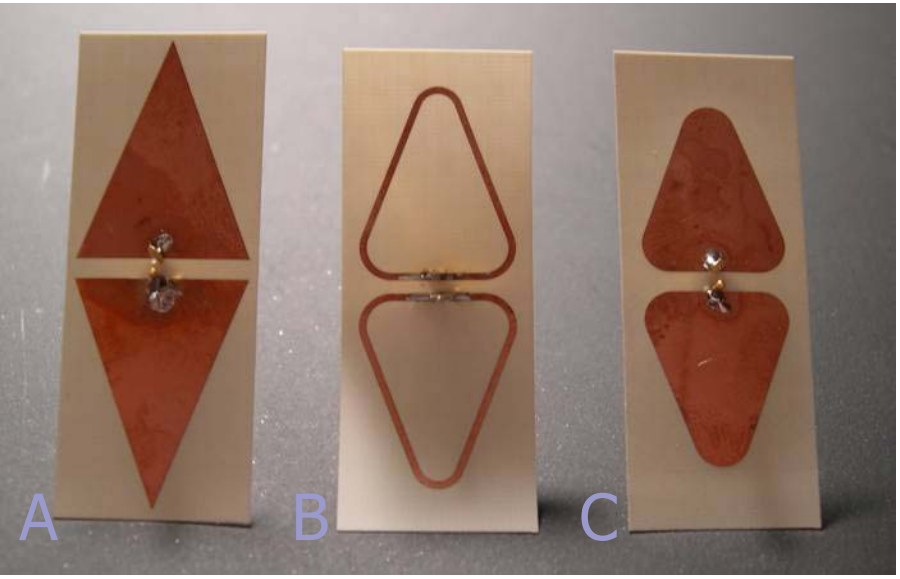
A wideband impedance match indicates optimal reception for a wideband pulse

Antenna Designs

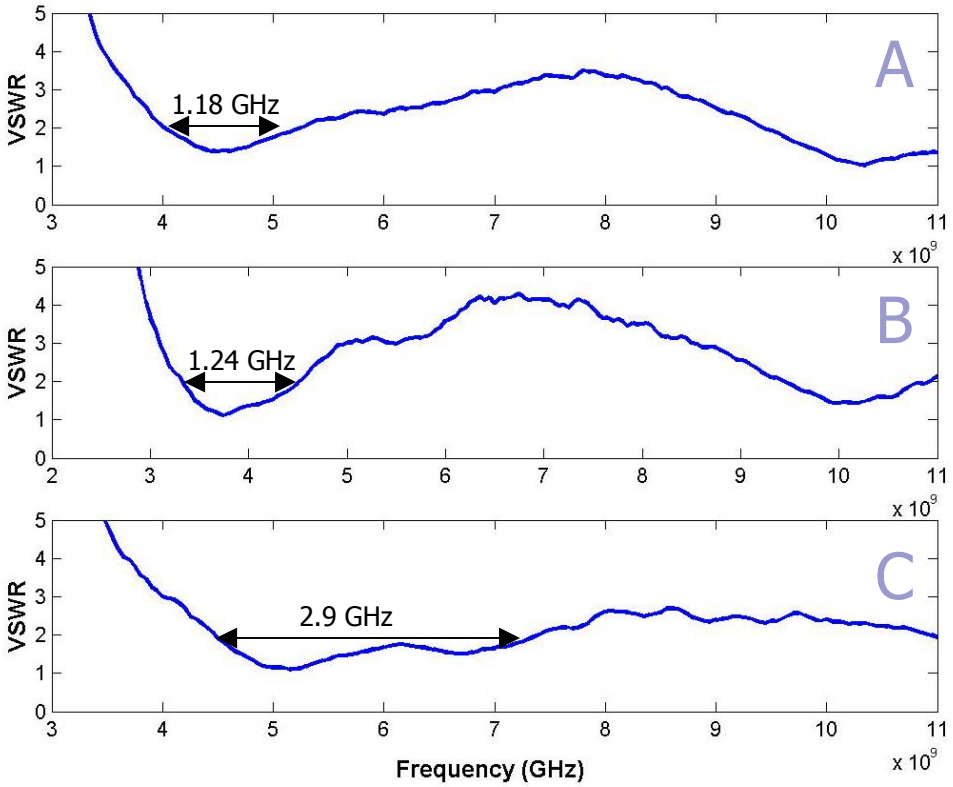
- Diamond Dipole
- Elliptical Planar Antennas

- CDM
- Spiral

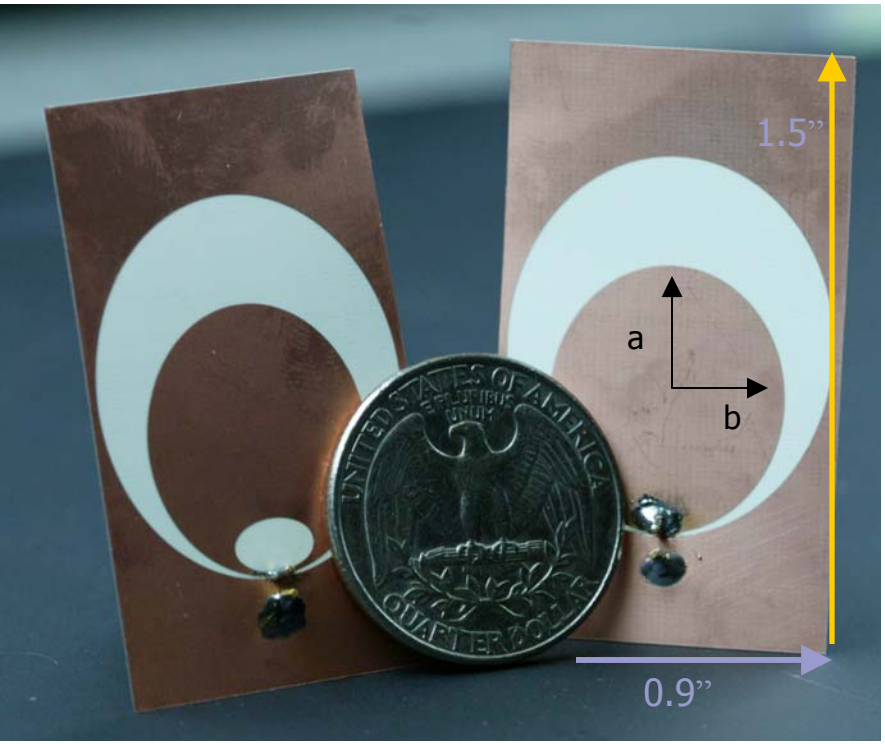
Diamond Dipole

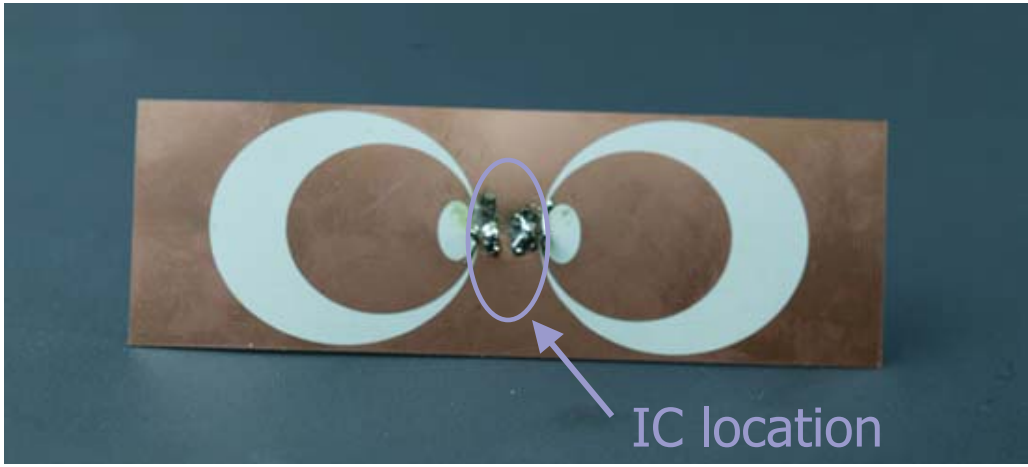


Time Domain Diamond Dipole



Single Ended and Differential Elliptical Antennas

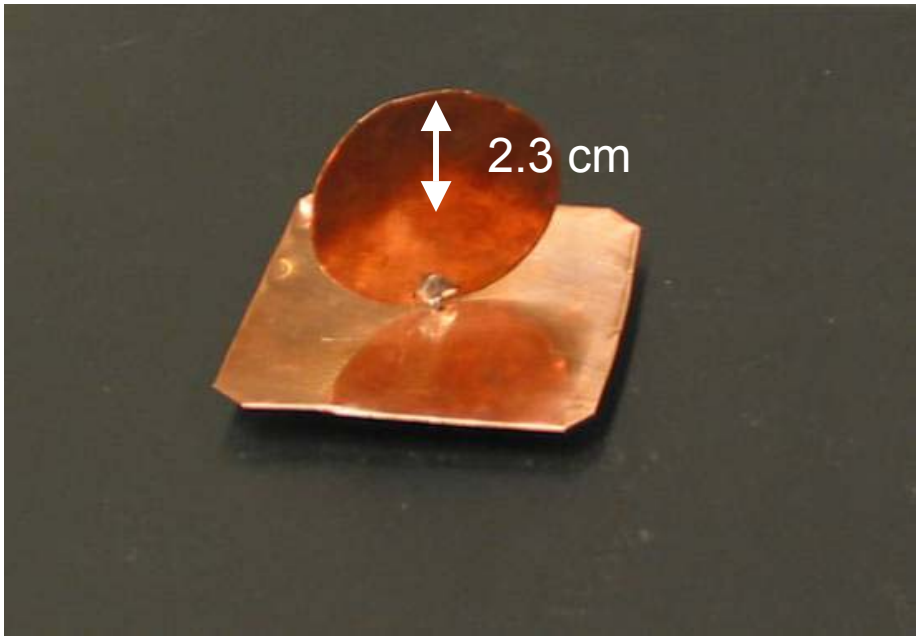


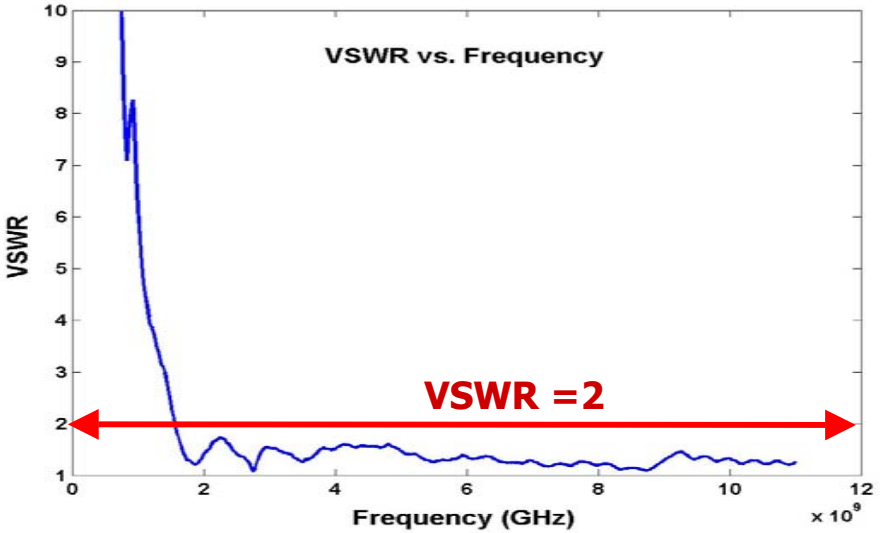


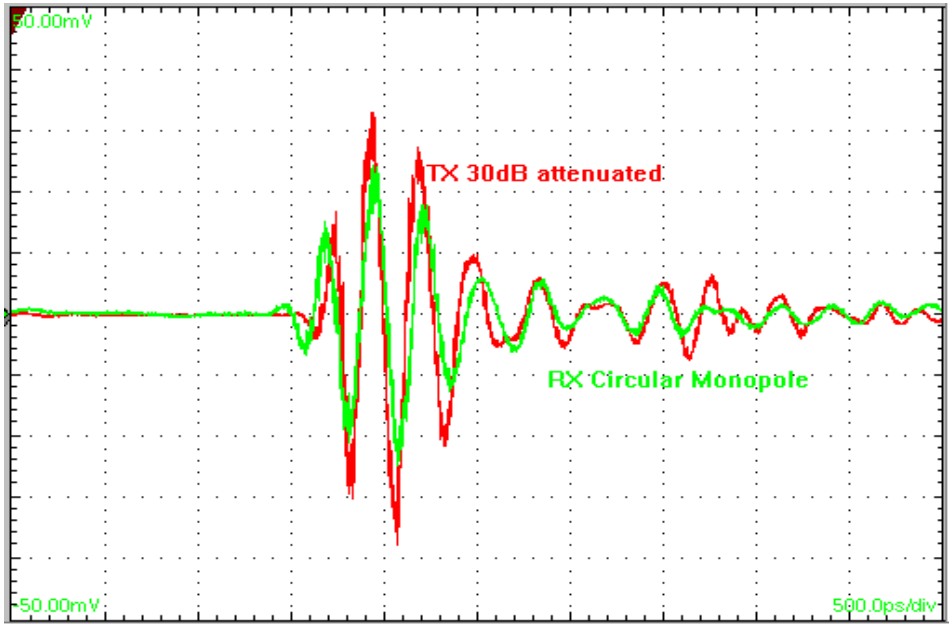
$$f_L = \frac{c}{\lambda} = \frac{30 * 0.24}{L + r} GHz$$

J. Powell and A. Chandrakasan, “Differential and Single ended Elliptical Antennas for 3.1-10.6 GHz Ultra Wideband”, AP-S 2004.

Circular Disc Monopole





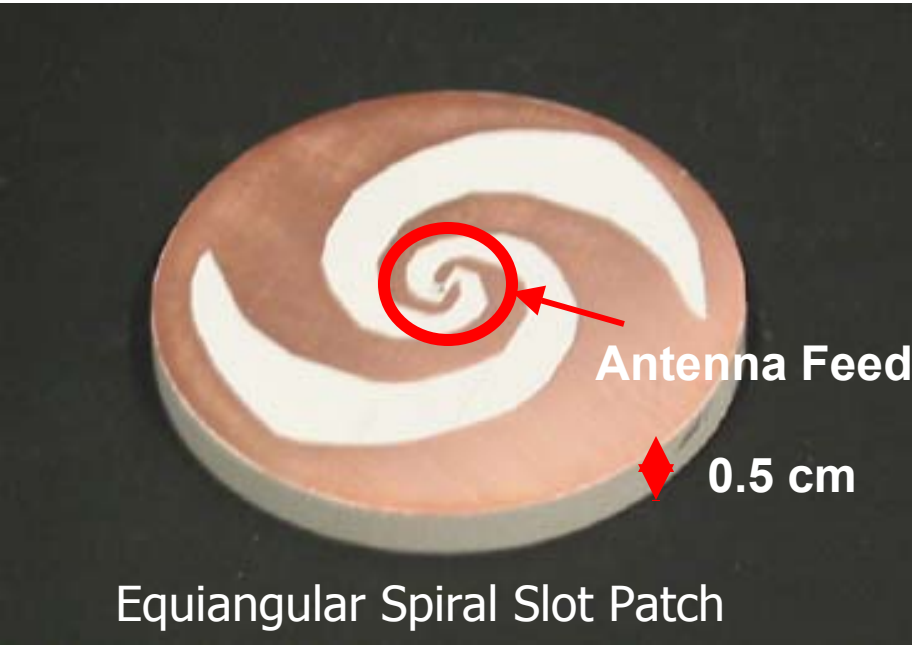


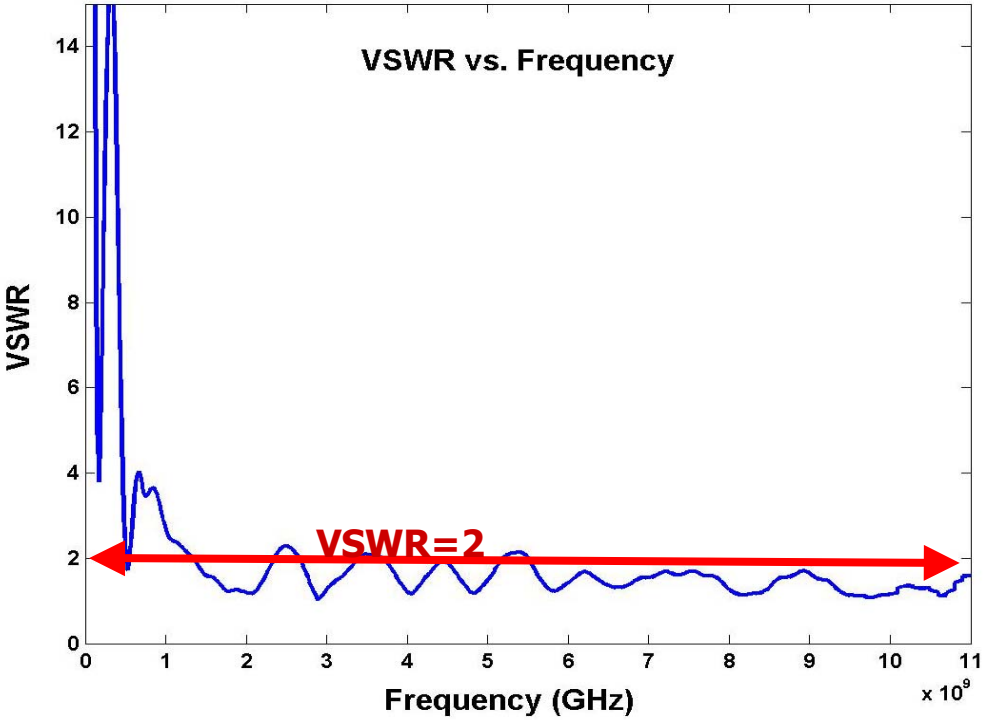
VSWR < 1.5 ➔ Power loss < 4%

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

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

Spiral Equiangular Slot Patch





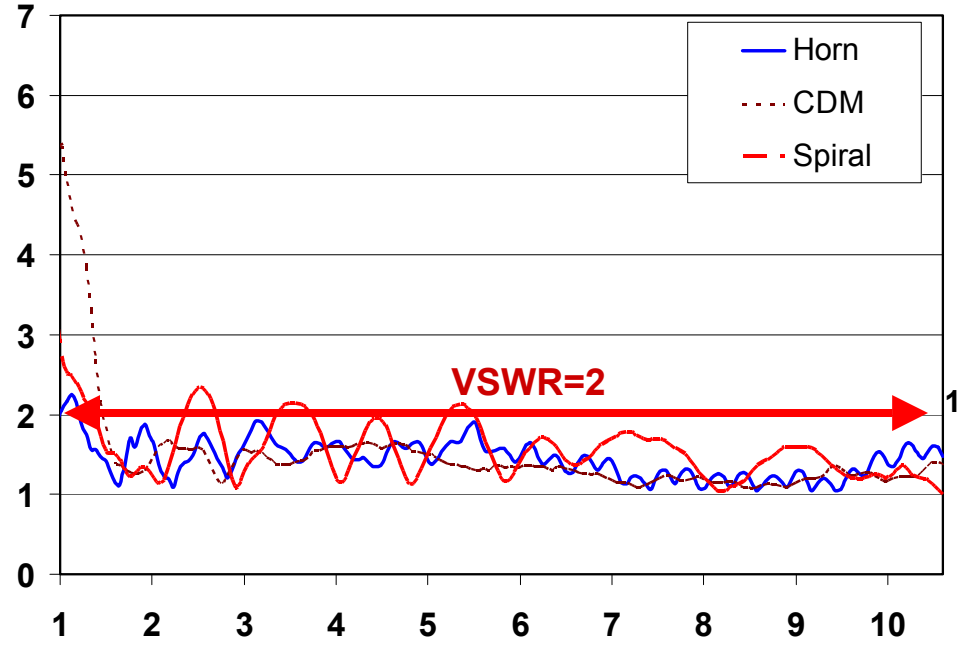
Expansion rate = .38
Total Arm Length = 6 cm
Outer Radius = 2.25 cm

Designed in Remcom's XFDTD

Back plane allows for use with PEDs

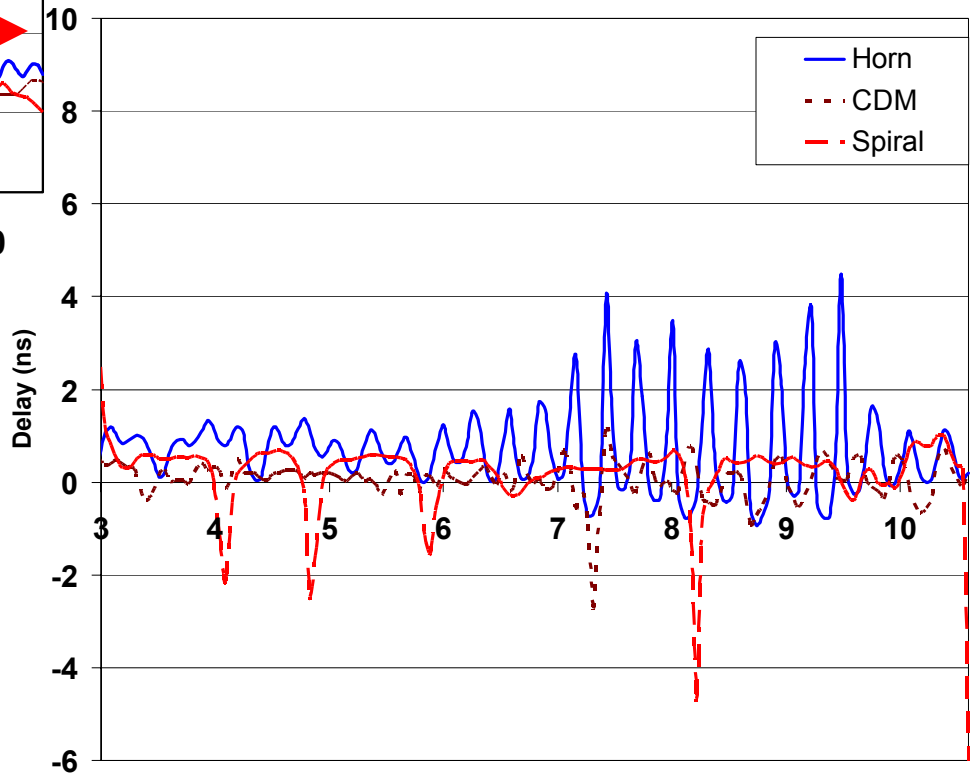
Fabricated with Omax waterjet and PCB milling router

VSWR and Group Delay

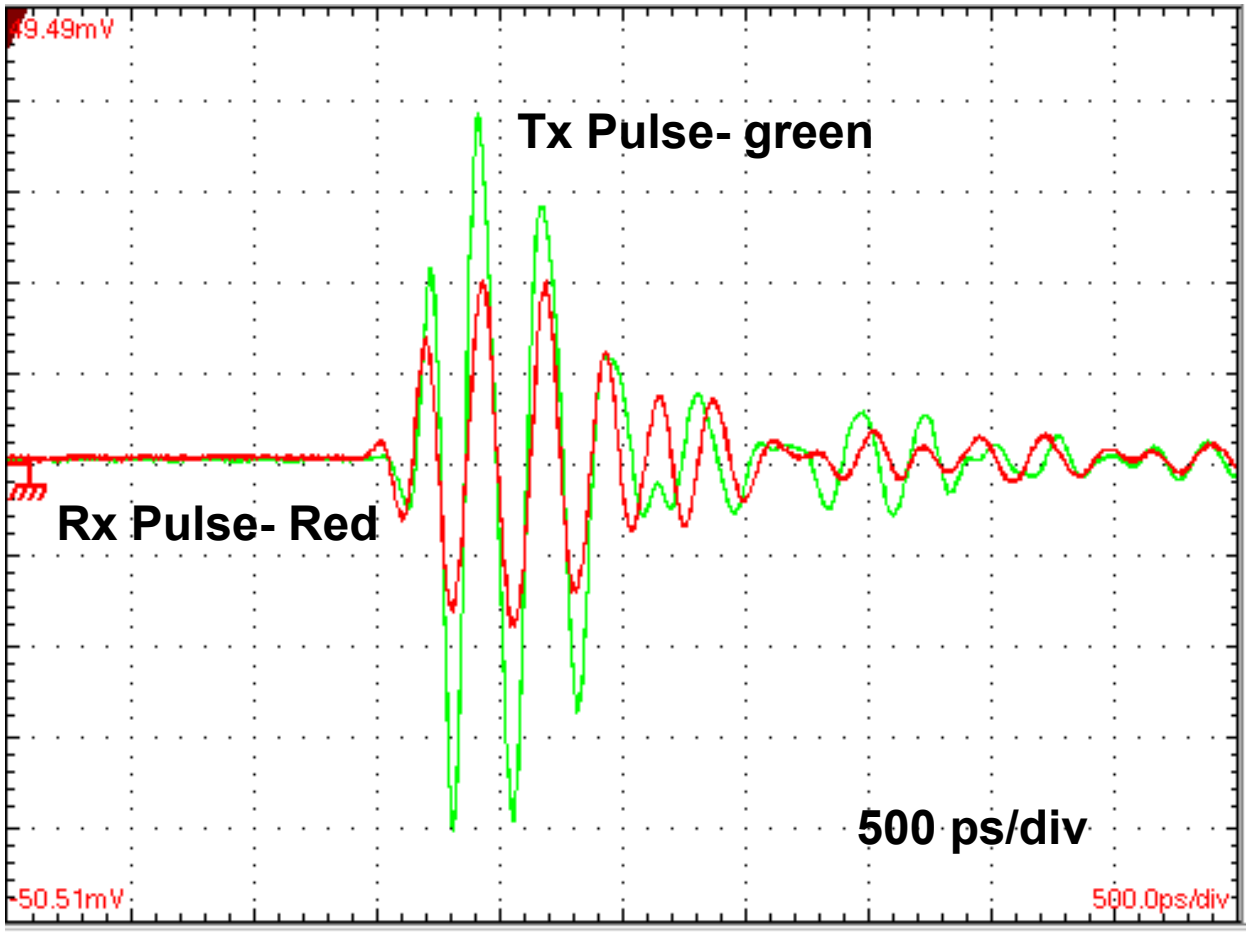


VSWR vs. Frequency (GHz)

Group Delay vs. Frequency (GHz)

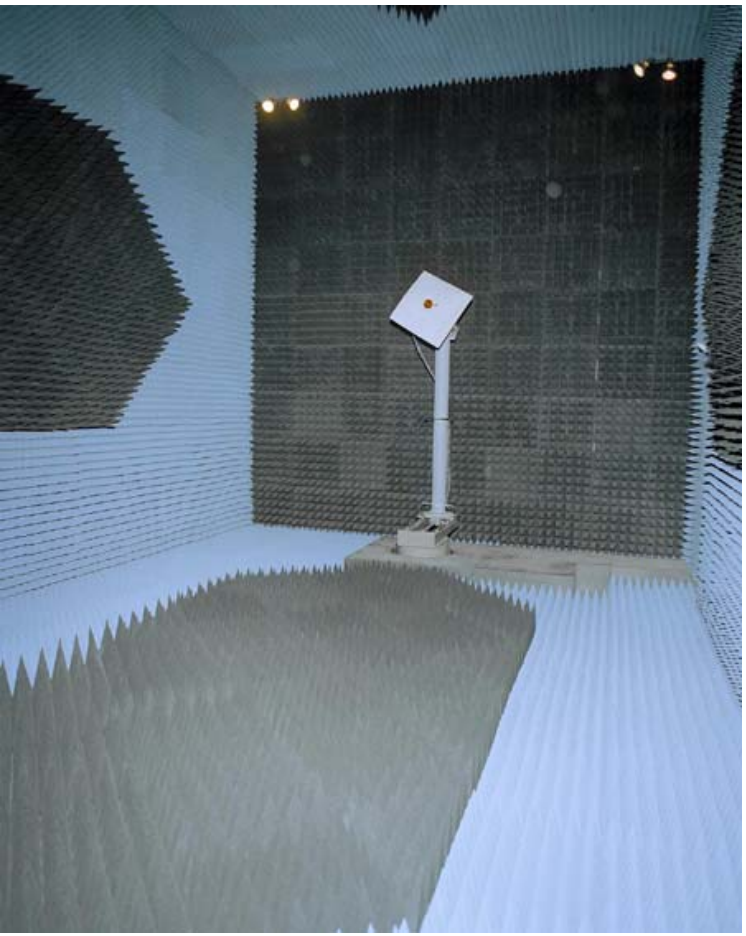


Pulse Fidelity Time Domain Plot

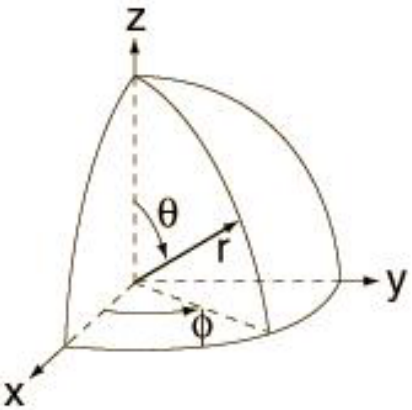


Taken from TDS 8000 Digitizing Oscilloscope

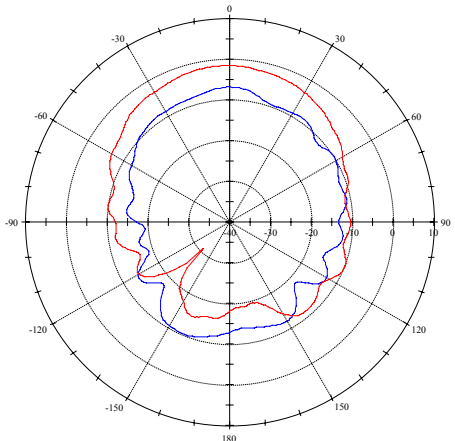
Antenna Results- Chamber

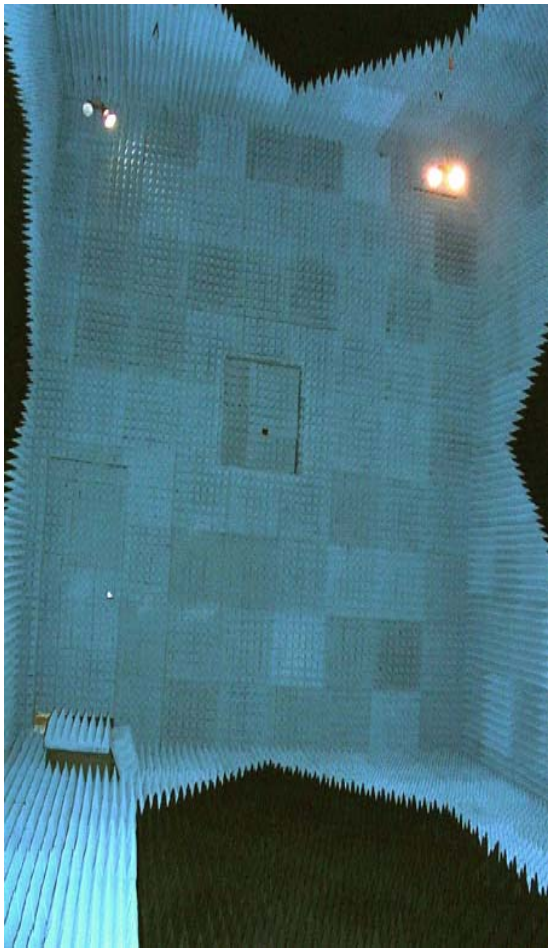


Photos courtesy Lincoln Labs



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





Antenna Results- Chamber

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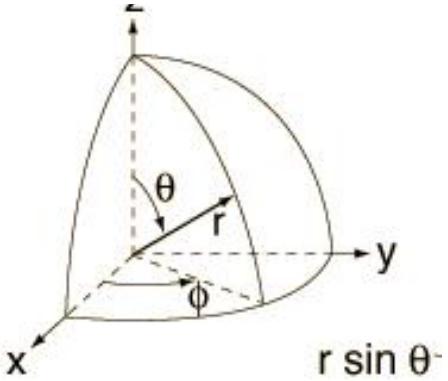
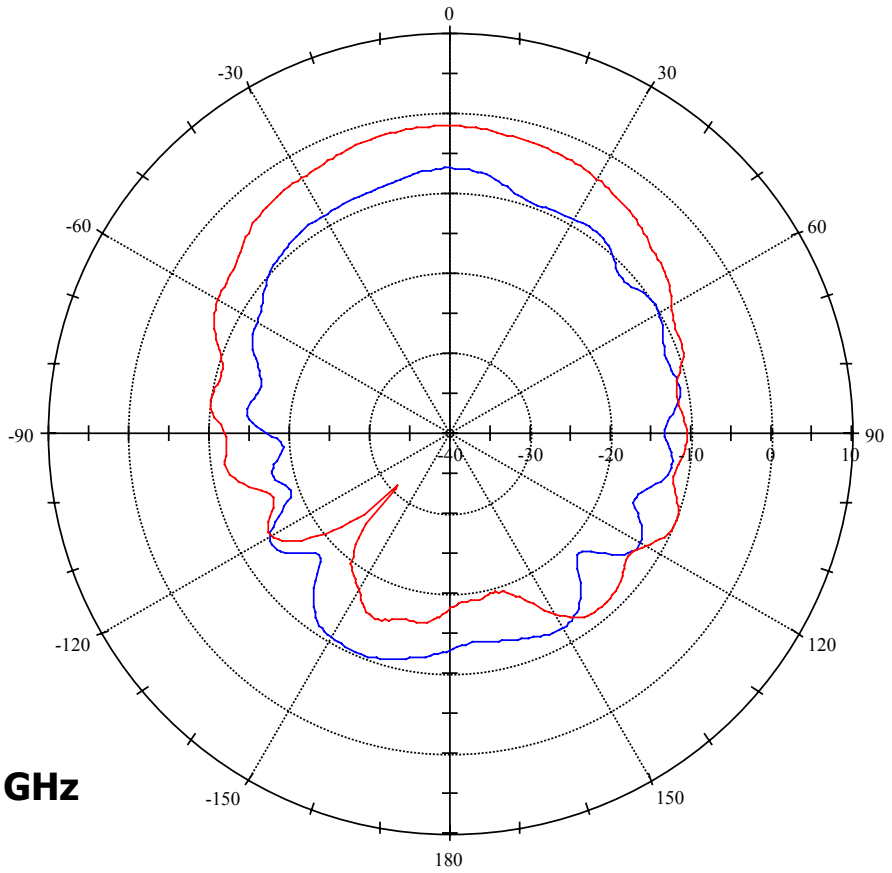


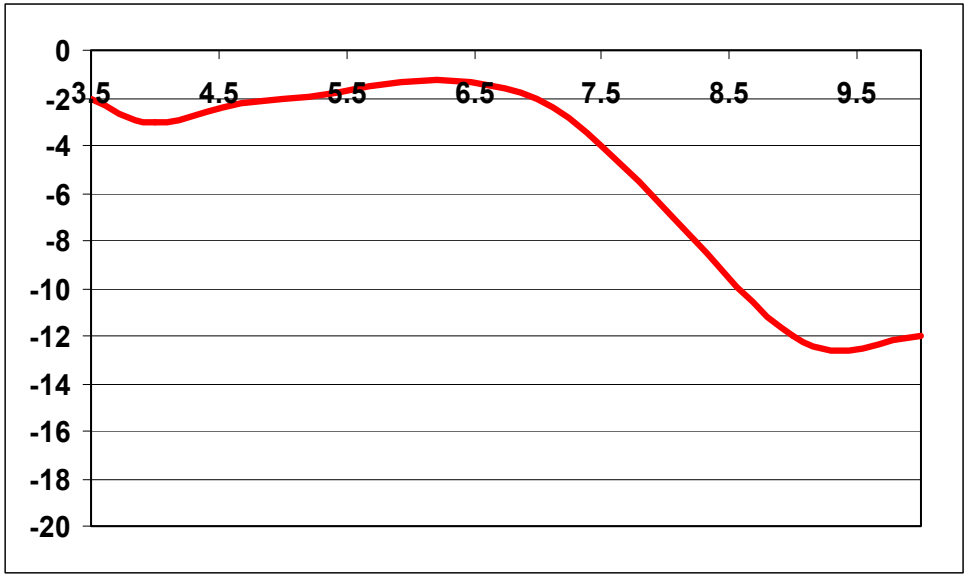


3.5 GHz

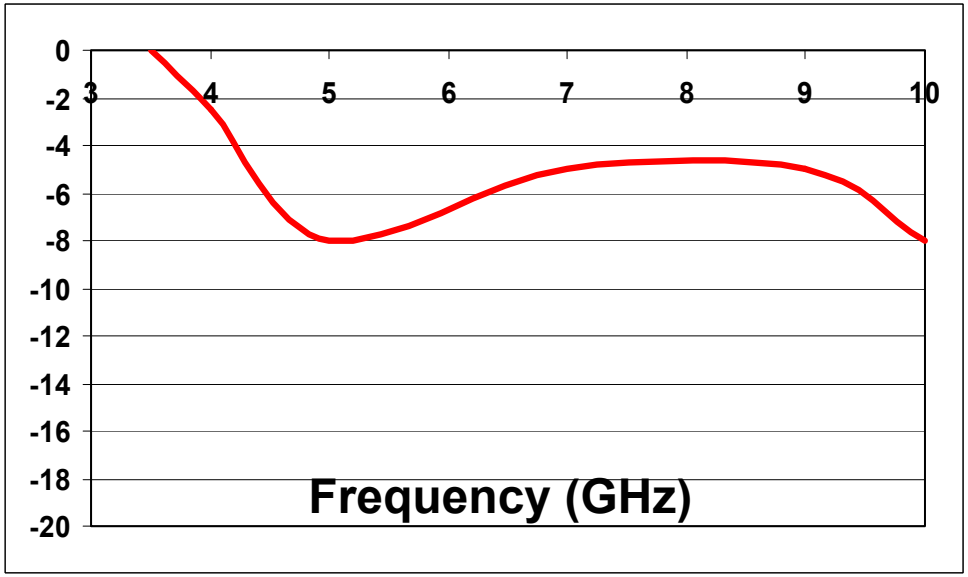
Lincoln Laboratory Measured Pattern: Azimuth =Blue, Elevation = Red

Gain vs. Frequency

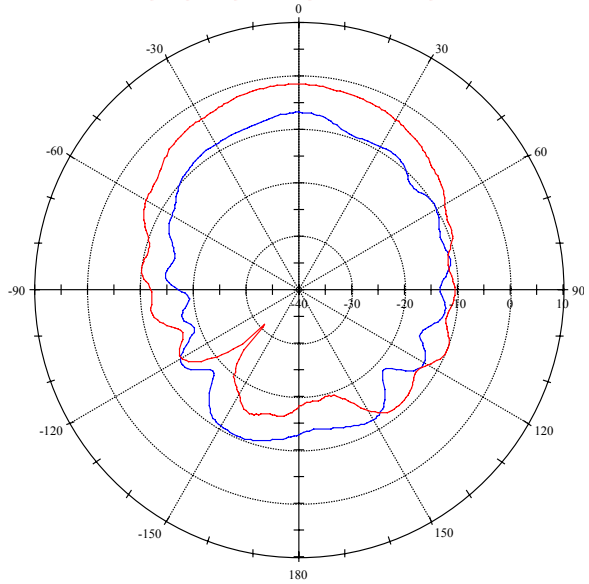
Vertical Polarization



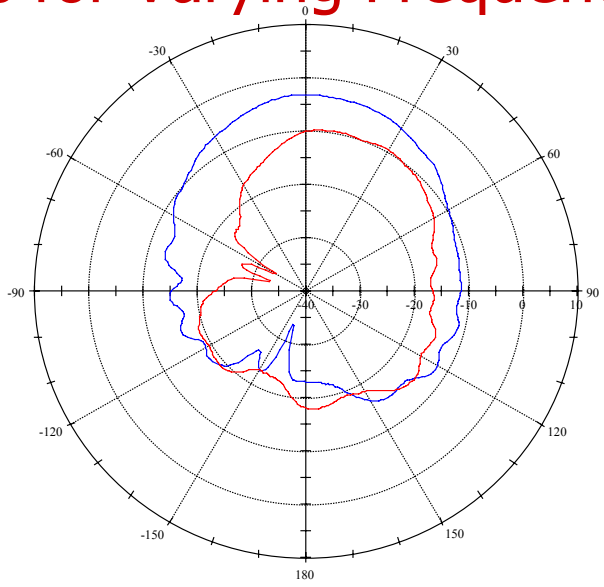
Horizontal Polarization



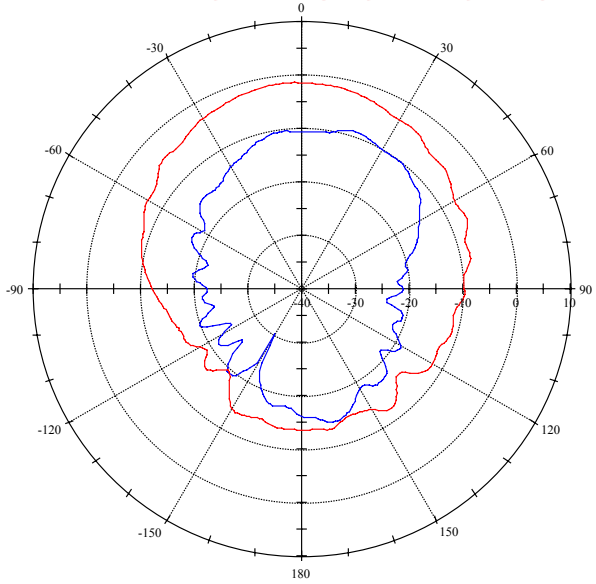
Radiation Patterns for Varying Frequency- Vertical Polarization



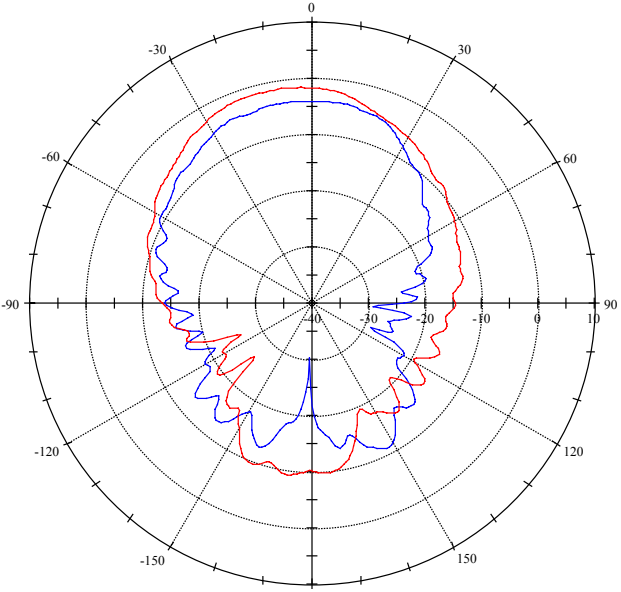
3.5 GHz



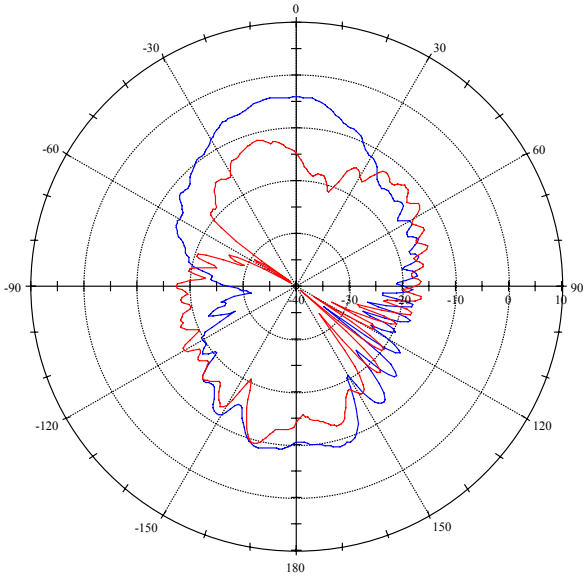
4 GHz



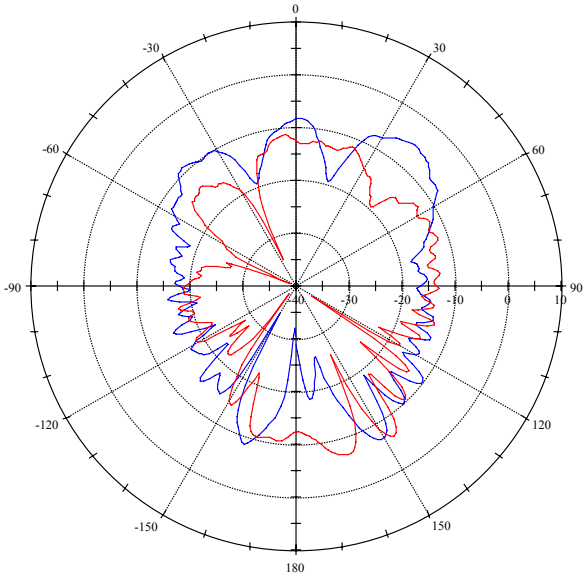
5 GHz



7 GHz

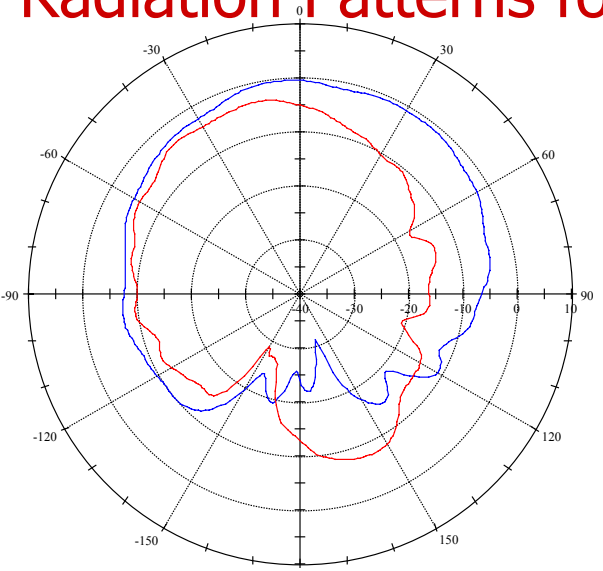


9 GHz

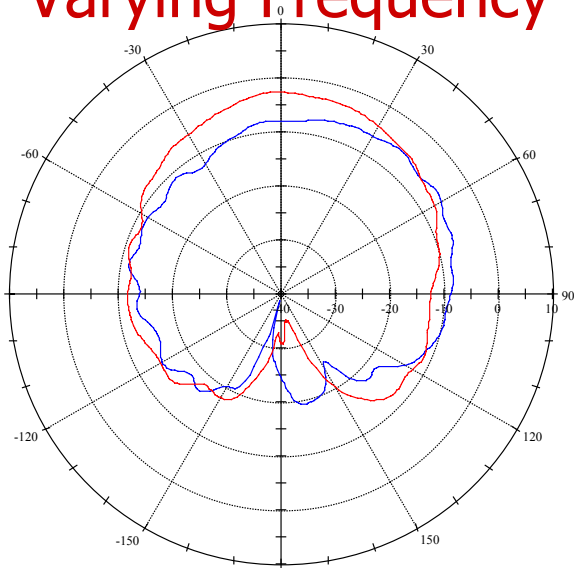


10 GHz

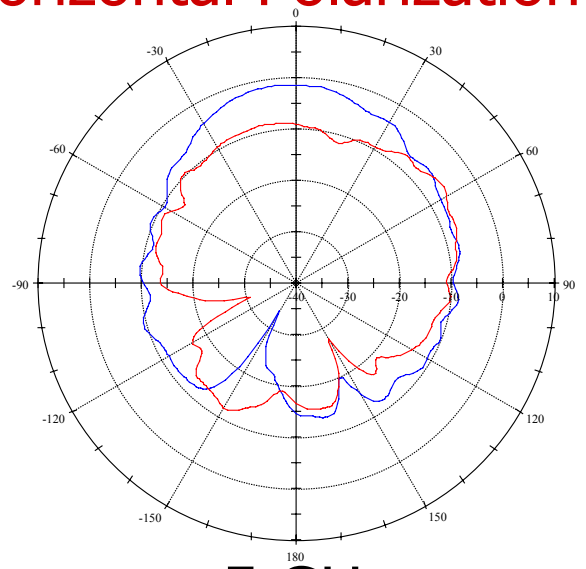
Radiation Patterns for Varying Frequency- Horizontal Polarization



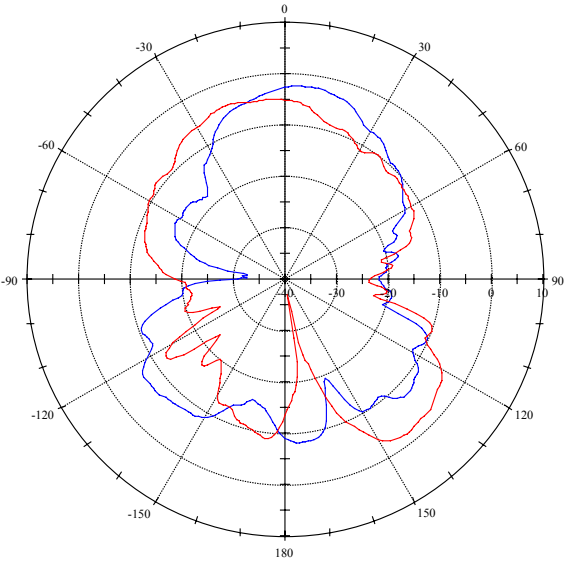
3.5 GHz



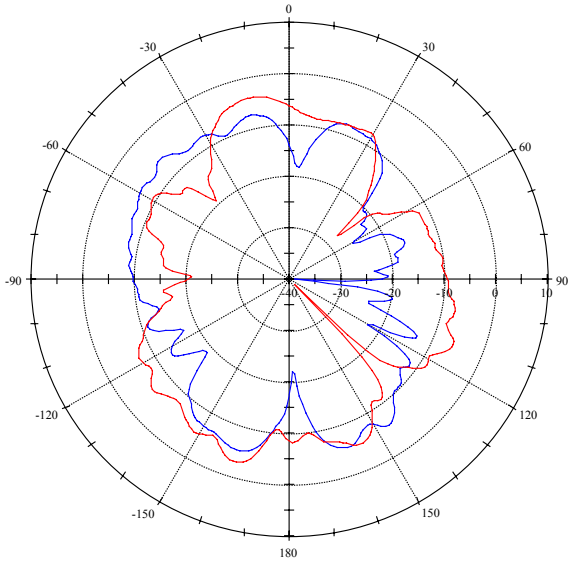
4 GHz



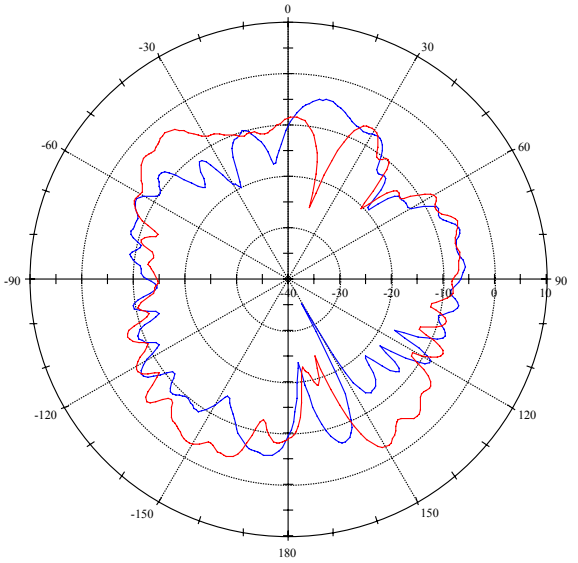
5 GHz



7 GHz



9 GHz



10 GHz

Summary

- UWB Antenna Designs
  - VSWR < 2 for 3.1- 10.6 GHz
  - Physically Small Size
  - Good Pulse Fidelity
  - Consistent gain patterns
- Discrete System Implementation
- Future Work: System Considerations