
FRAGILE

Ultra Wideband Antenna – Senior Project

By: Ross Stange

Advisor: Dr. Prasad Shastry

Bradley University

Outline of Presentation

- Summary of Project
  - Introduction to Antennas
  - Introduction to UWB
- Block Diagram of UWB Antenna
- Picture of Reference Antenna
- Work to Change Reference Antenna into UWB Antenna
- Simulations and Layouts
- Information Received from Cunningham Graphics
- Equipment List
- EE 409 (RF Comm Lab) Labs
- Goals and Completion of Goals
- Future Work
- Special Thanks and Questions

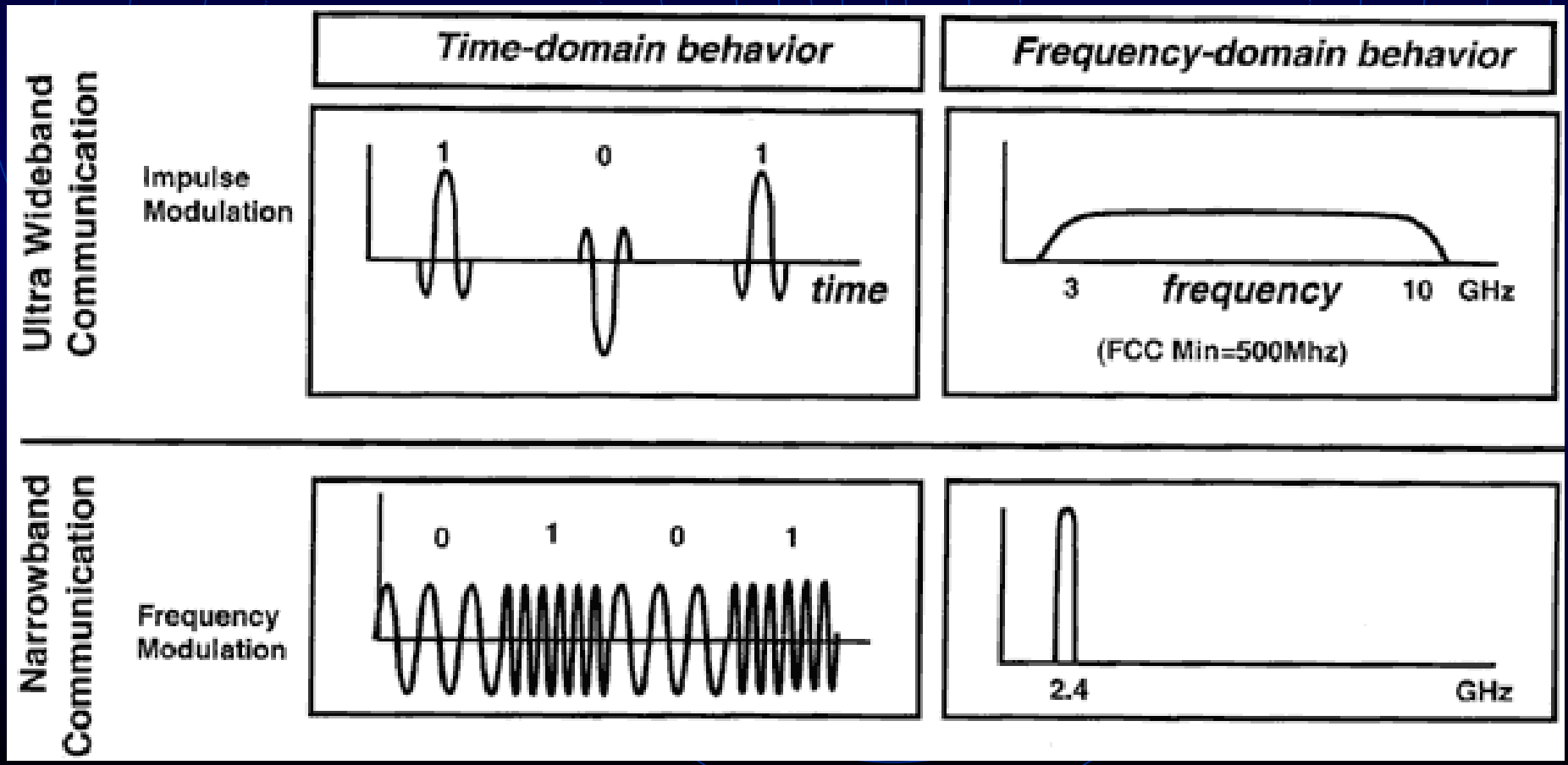
Intro to Antennas

- An antenna is a transducer between a guided wave propagating in a transmission line, and an electromagnetic wave propagating in an unbounded medium, like air.
- All antennas are both transmitting and receiving antennas.
- Car antenna mainly in receiving mode

Intro to UWB

- UWB is defined as a system having a bandwidth greater than 500 megahertz (MHz).
- UWB signals are pulse-based waveforms compressed in time, instead of sinusoidal waveforms compressed in frequency.

Intro to UWB (cont.)



Intro to UWB (cont.)

- Applications of Project

- Low Energy (Power) Levels for Short-Range High Speed Radio Communications
- Range is about 10 meters maximum

Importance and Purpose of Project

- Importance
  - UWB is becoming a form of new technology
  - UWB Antenna can be used to communicate wirelessly over a short distance using less power
- Project Purpose
  - To build a working UWB Antenna.
  - Learn the process of optimizing an antenna.

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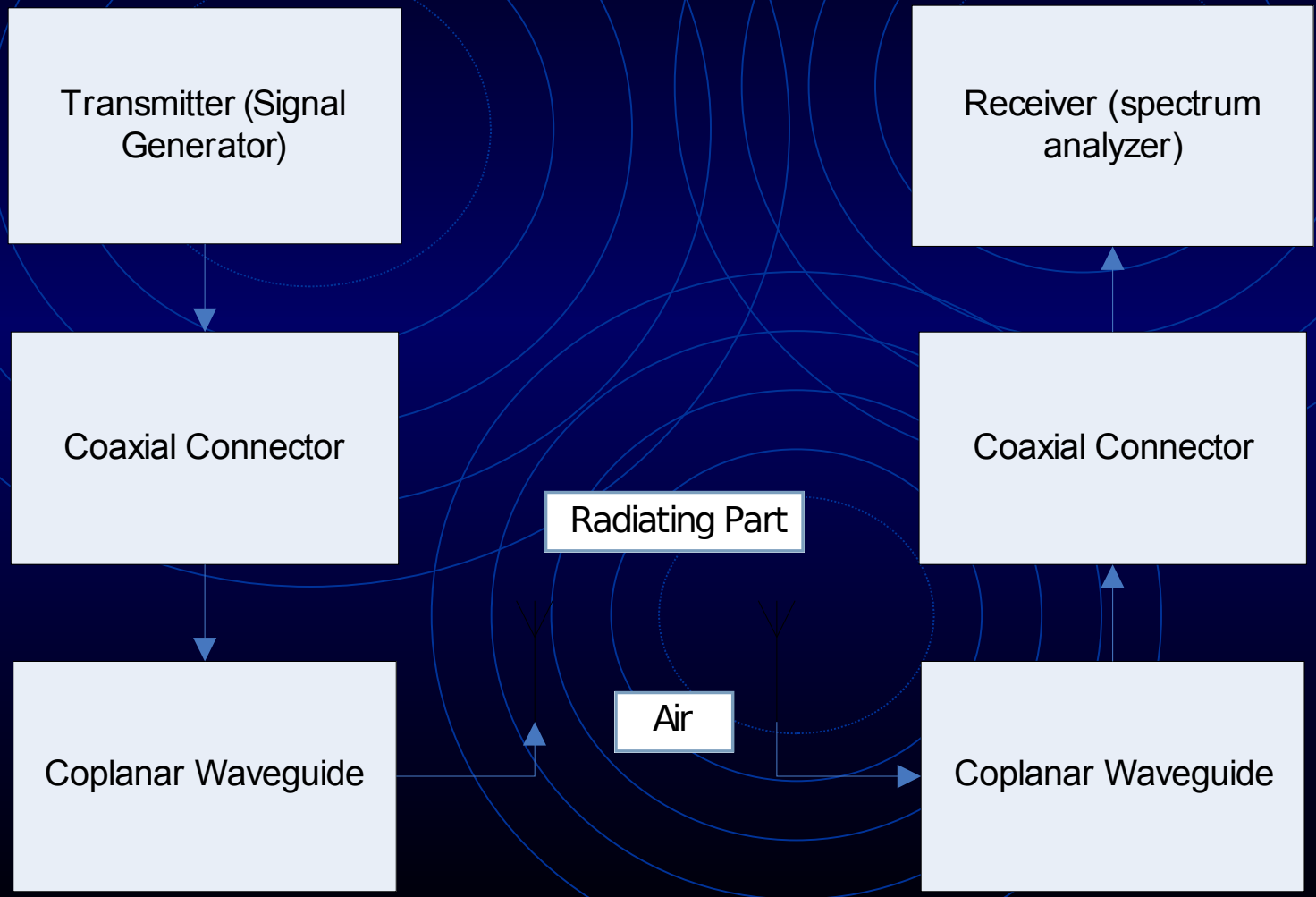
Block Diagram of UWB Antenna



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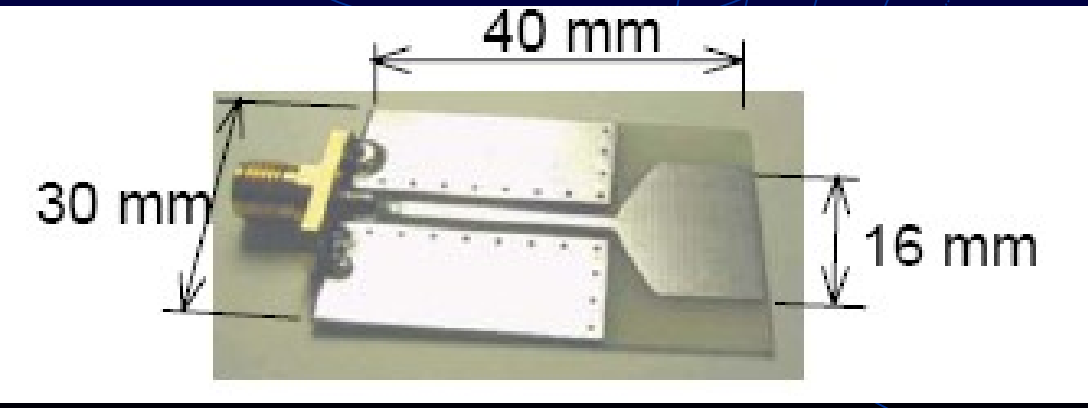
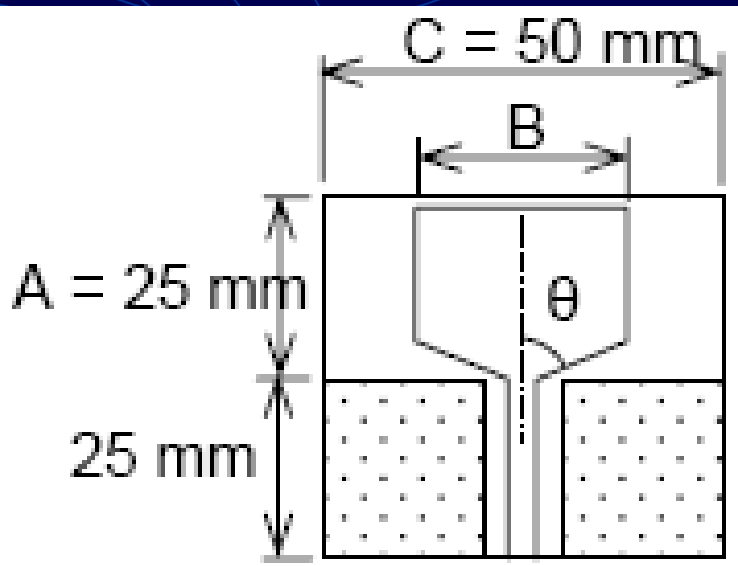
Picture of Reference Antenna

- Picture of a Monopole Antenna [Left = Final (Optimized) Result] [Right = Initial Set-Up -- from Fujitsu
- Final Values: $\theta = 63°$ B = 16 mm A = 15 mm





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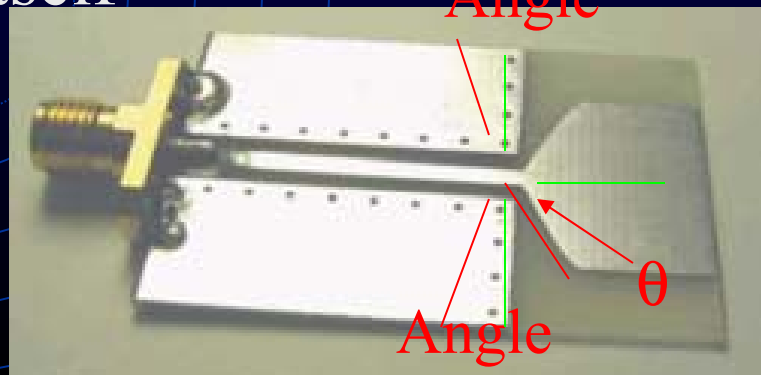
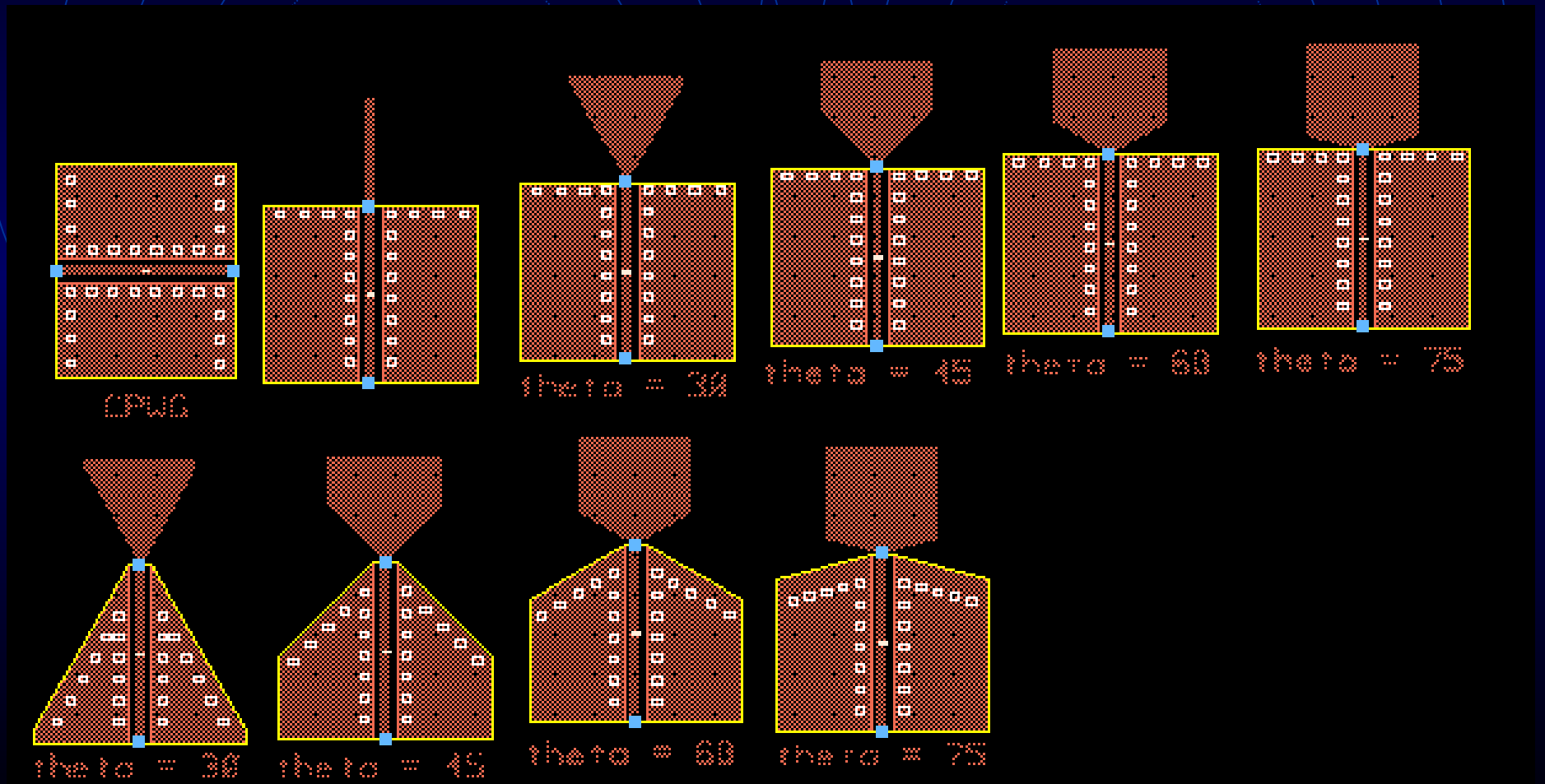
Work to Change Reference Antenna to UWB Antenna

- Reference Antenna to be designed first – gap and width of center conductor unknown
- ∀ θ = 63° (Original Value)
  - Will be changed to 0°, 30 °, 45 °, 60°, and 75 °.
- Change shape of Coplanar Waveguide
  - Trapezoidal (Angle = 90 - θ)
- Test Coplanar Waveguide by itself
  - At 0°



Work to Change Reference Antenna to UWB Antenna



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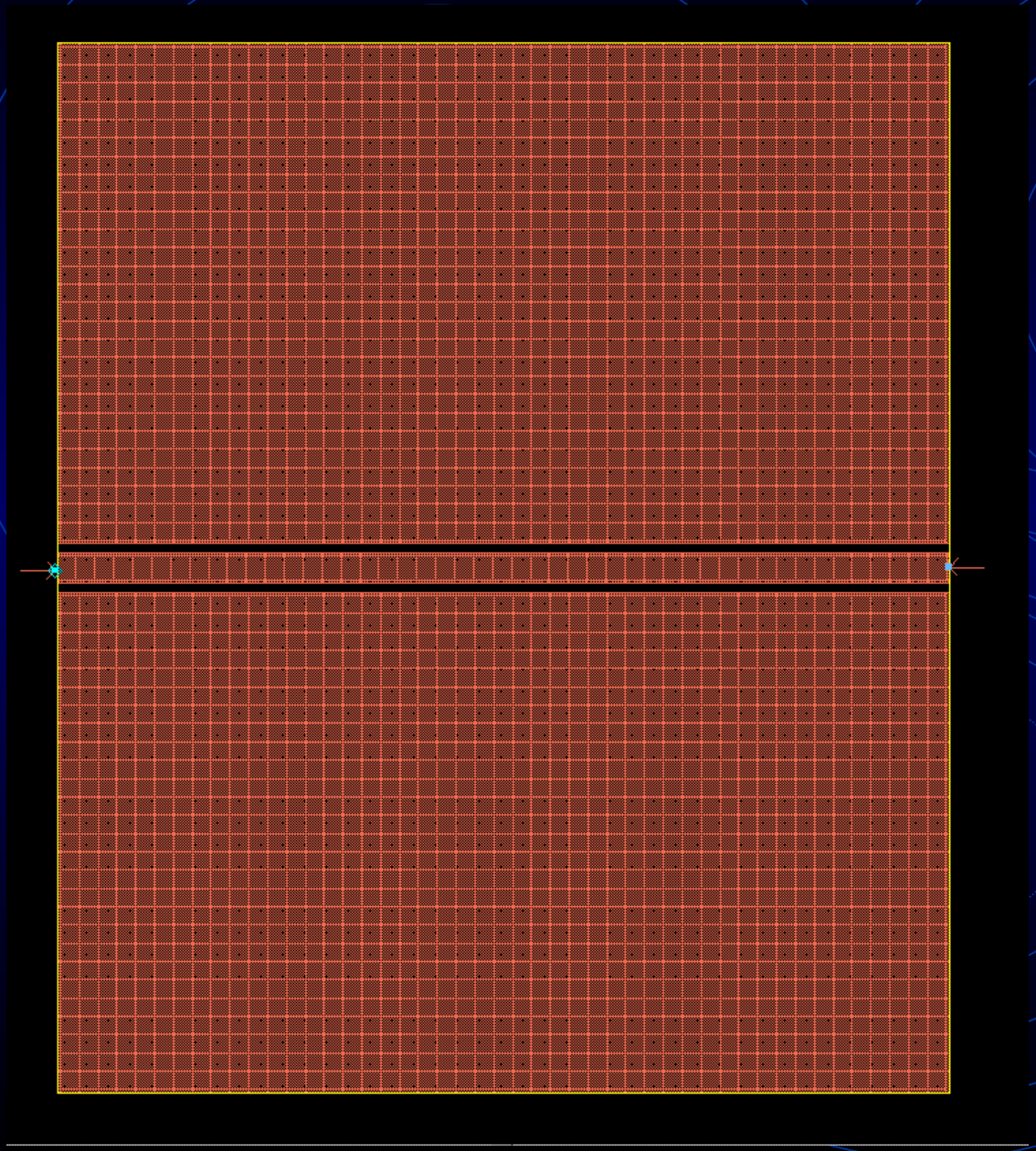
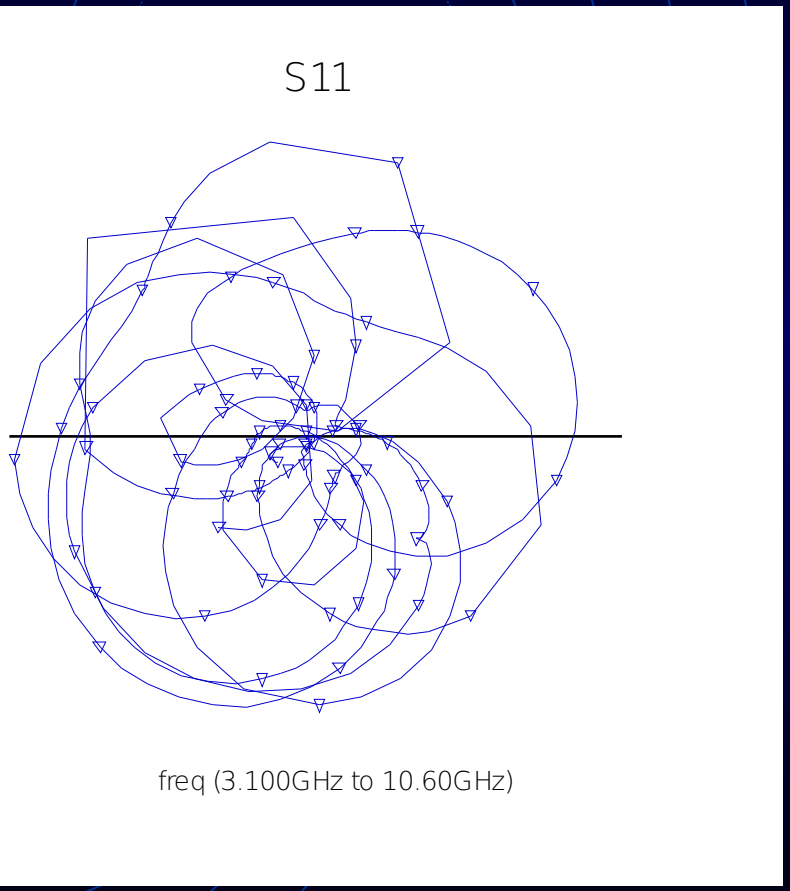
Simulation and Layouts (Early Results)



Coplanar Waveguide
for Simulation 1

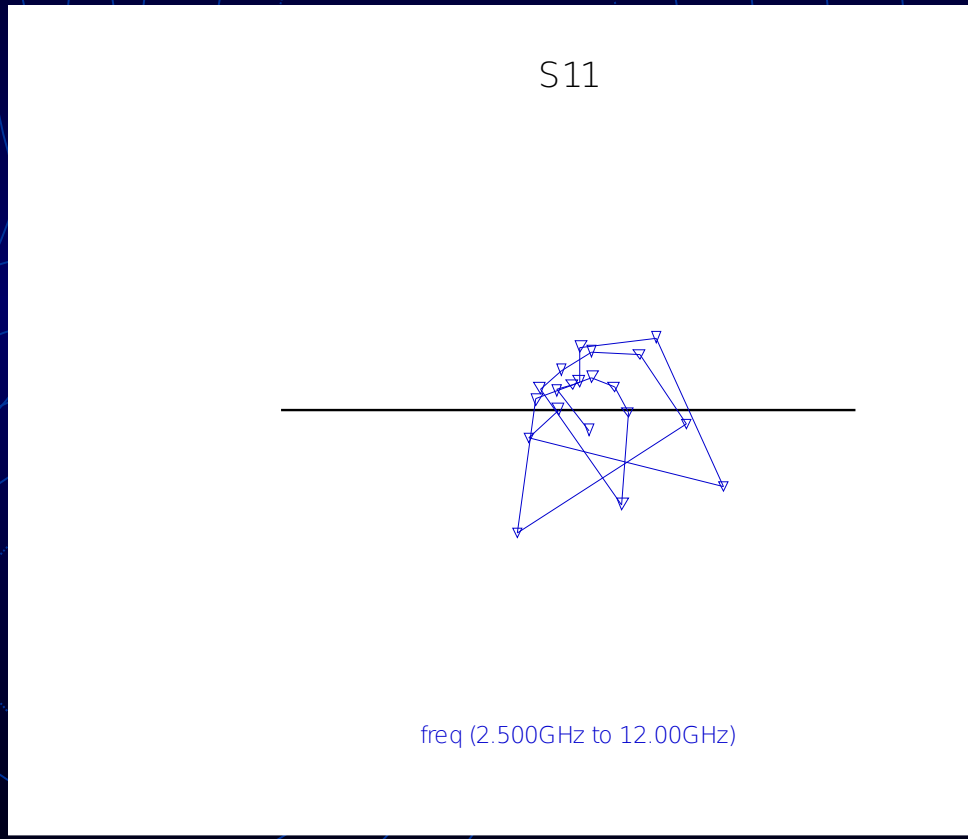
Simulation and Layouts (Early Results)

- Simulation 1 – Bad Data
- Z0=50 Ohms (for all simulations)



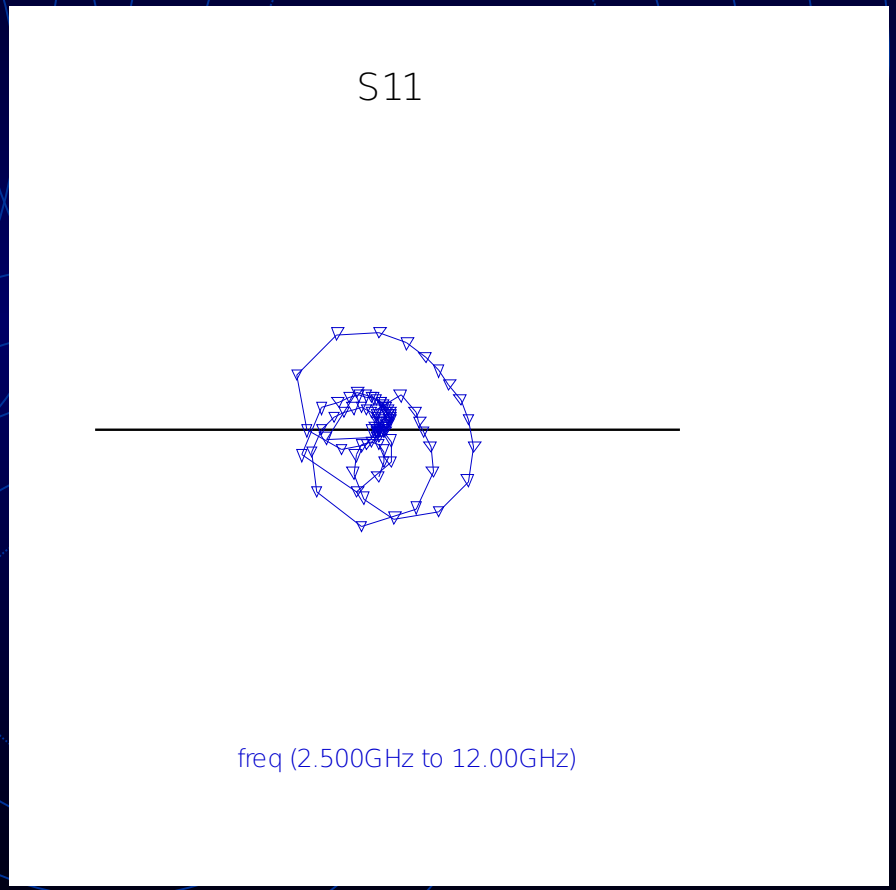
Simulation and Layouts (Early Results)

- Simulation 2 – better results
- Date Simulation Done – 3/6/2008
- Center Conductor Width and Gap Changed



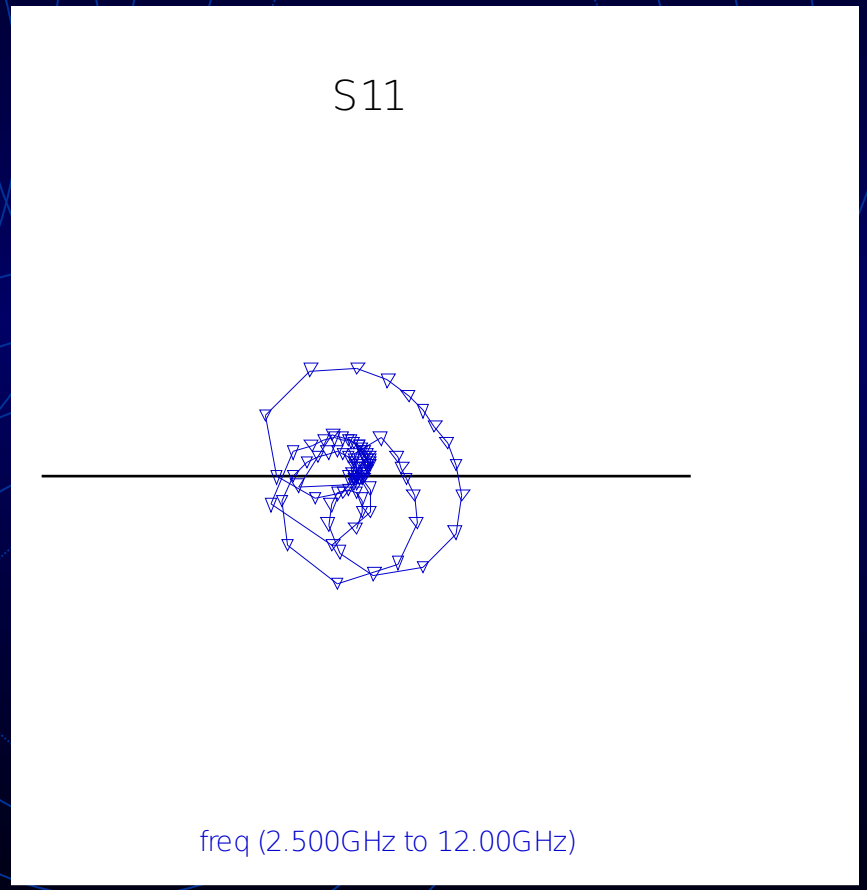
Simulation and Layouts (Early Results)

- Simulation 3
- Date Simulation Done – 3/13/2008
- Thickness of copper = 1 oz., which is different to Simulations 1 and 2



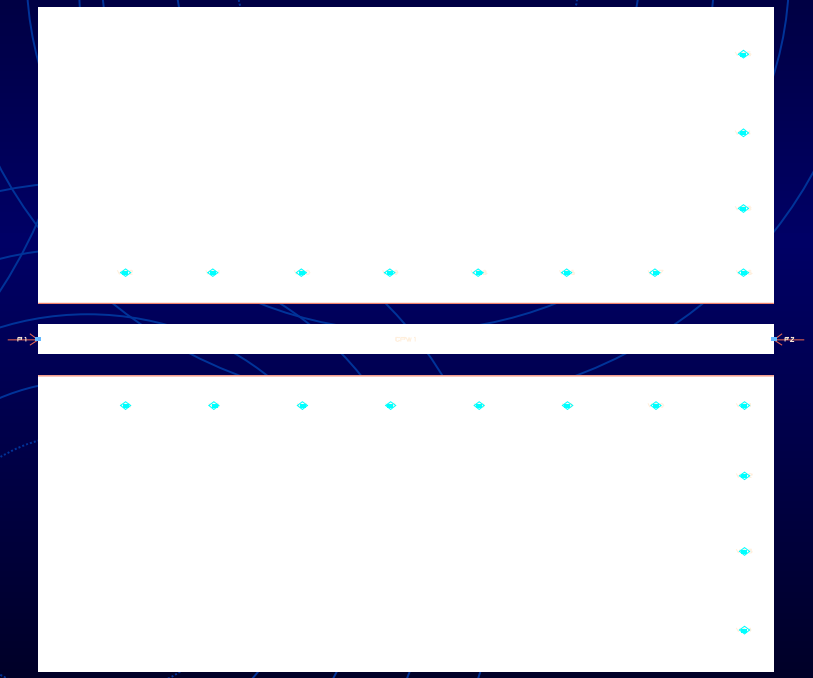
Simulation and Layouts (Early Results)

- Simulation 4
- Date Simulation Done – 3/14/2008
- Simulation 4 similar to Simulation 3 because only width and gap change.



Simulations and Layouts (Final Decisions)

- Final Layout of Coplanar Waveguide
- Width = 52.6 mils = 1.336 mm
- Gap = 38 mils = 0.965 mm
- Side Plane = 626.25 mils = 13.37 mm
- Width + 2(Gap) + 2(Side Plane) = 30 mm
- 1.336 mm + 2(0.965 mm) + 2(13.37 mm) = 30.006 mm
- 30.006 mm is very close to 30 mm



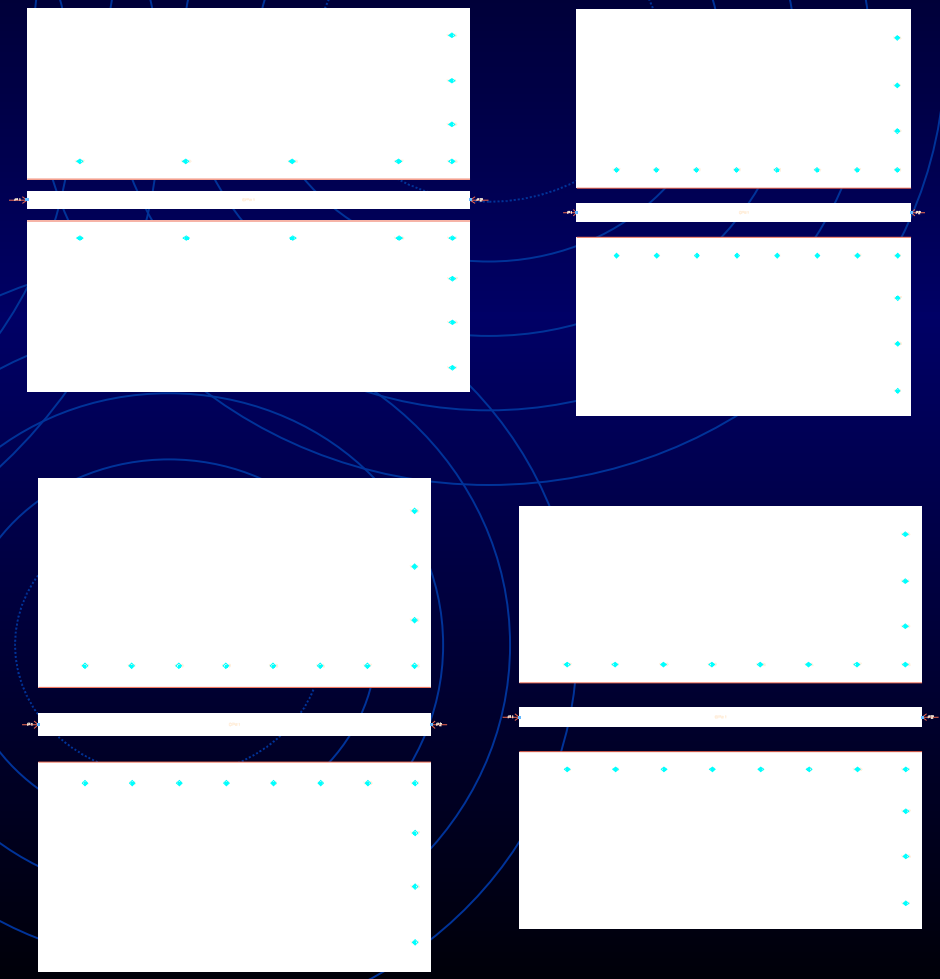
Simulations and Layouts (Final Decisions)

- Results from final layout of coplanar waveguide
- 9GHz – only questionable spot

freq	Zreal	Zimg
3.000 GHz	49.067	2.548
3.500 GHz	50.438	2.301
4.000 GHz	52.014	2.513
4.500 GHz	53.215	1.370
5.000 GHz	53.308	-0.310
5.500 GHz	52.912	-1.954
6.000 GHz	44.660	6.011
6.500 GHz	49.662	2.117
7.000 GHz	50.505	1.398
7.500 GHz	50.368	0.297
8.000 GHz	49.132	-0.275
8.500 GHz	50.295	-0.106
9.000 GHz	5.944	-20.212
9.500 GHz	47.456	4.187
10.00 GHz	49.934	1.162
10.50 GHz	48.151	-3.199
11.00 GHz	47.305	-2.876

Simulations and Layouts (Final Decisions)

- Other Layouts to choose from
  - Less via holes (top left)
  - Gap=45 mils
    Width=54.2mils (top right)
  - Gap=65mils
    Width=57.15mils
    (bottom left)
  - Gap=73.28mils
    Width=58mils
    (bottom right)



Simulations and Layouts (Final Decisions)

- Results from other layouts

Less via holes

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11.00 GHz	47.305	-2.876

Gap = 45 mils

freq	Zr	Zi
3.000 GHz	49.209	2.274
3.500 GHz	50.355	1.687
4.000 GHz	51.330	1.562
4.500 GHz	51.797	0.691
5.000 GHz	51.583	-0.204
5.500 GHz	51.609	-1.121
6.000 GHz	45.558	5.333
6.500 GHz	49.747	1.848
7.000 GHz	50.165	0.414
7.500 GHz	49.122	-0.795
8.000 GHz	47.123	-0.731
8.500 GHz	48.209	0.355
9.000 GHz	7.116	-17.221
9.500 GHz	47.639	4.124
10.00 GHz	49.951	0.440
10.50 GHz	47.400	-4.211
11.00 GHz	46.425	-2.795

Gap = 65 mils

freq	Zr	Zi
3.000 GHz	49.453	1.737
3.500 GHz	50.133	0.506
4.000 GHz	49.896	-0.198
4.500 GHz	49.028	-0.456
5.000 GHz	48.345	0.091
5.500 GHz	48.967	0.591
6.000 GHz	46.883	4.261
6.500 GHz	49.882	1.101
7.000 GHz	49.332	-1.470
7.500 GHz	46.656	-2.633
8.000 GHz	43.650	-1.325
8.500 GHz	44.323	1.292
9.000 GHz	11.769	-11.140
9.500 GHz	47.905	4.047
10.00 GHz	49.883	-0.785
10.50 GHz	46.123	-5.713
11.00 GHz	43.000	-4.402

Gap = 73.28 mils

freq	Zr	Zi
3.000 GHz	49.510	1.600
3.500 GHz	50.055	0.167
4.000 GHz	49.450	-0.694
4.500 GHz	48.212	-0.757
5.000 GHz	47.418	0.194
5.500 GHz	48.184	1.094
6.000 GHz	47.157	4.029
6.500 GHz	49.907	0.878
7.000 GHz	49.061	-1.992
7.500 GHz	45.944	-3.104
8.000 GHz	42.749	-1.452
8.500 GHz	43.238	1.563
9.000 GHz	14.201	-9.009
9.500 GHz	47.939	4.074
10.00 GHz	49.848	-1.082
10.50 GHz	45.794	-6.070
11.00 GHz	41.861	-4.908

Simulations and Layouts (Final Decisions)

- Reasons for choosing Gap = 38 mils Width = 52.6 mils
  - Number of via holes equals reference antenna's amount
  - Time constraint
    - Side plane values are ready calculated
    - Simulation of coplanar waveguide without via holes already done (all values less than 5 Ohms from 50 Ohms)
    - Bad reading at 9 GHz is from via holes (they create a(n) inductive and capacitive impedance
  - Gap = 65 mils and Gap = 73.28 mils are becoming to large

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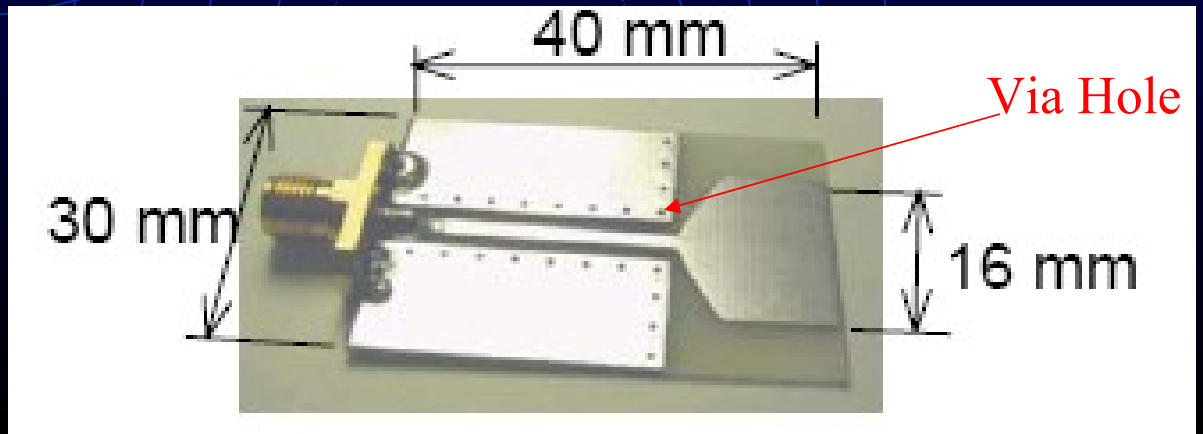
Information from Cunningham Graphics

- Printed Circuit Board – 31 mil thickness
- 1 Oz. Copper thickness [Will increase due to electro-platting which was necessary due to via holes (platted-through holes)]
- Where antennas will be fabricated (with via holes)
- Via holes are used to connect the ground plate to upper conductor plate so it wouldn't create a T-line



Information from Cunningham Graphics

- Telephone Conference with Bob Modica 2-21
- Possible Problem because of glass fiber amount
  - Each Company uses a different amount of glass fiber and epoxy
  - Just because the printed circuit board is a FR-4, does not mean it is exactly the same
  - Loss, dielectric constant can change

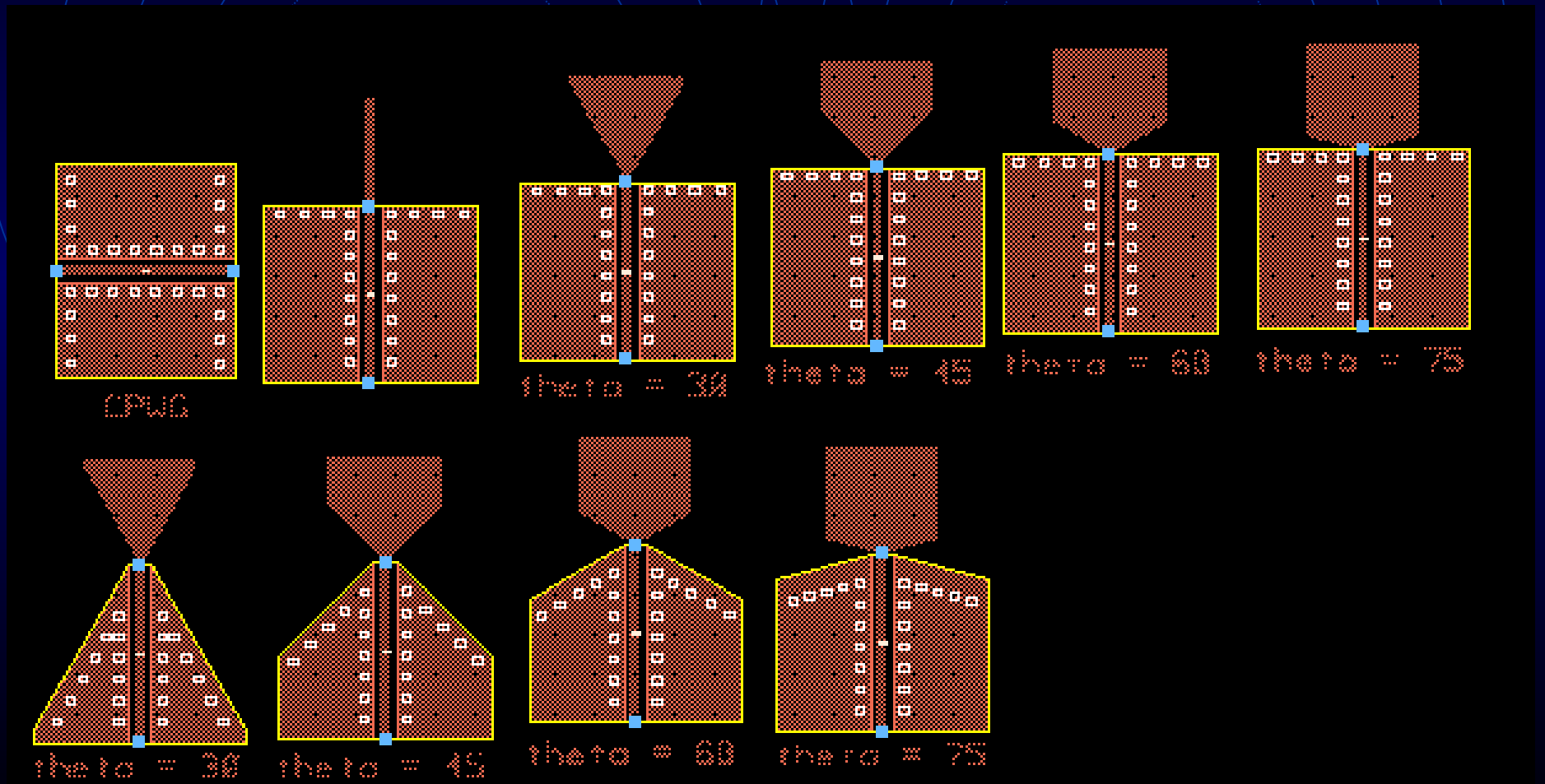
Information from Cunningham Graphics

- From Cunningham Graphics, actual specs:
  - FR-4 Printed Circuit Board will have a 30 mil core, 4.6 dielectric constant, copper plating of 2.6 mil, 100 micro-inches of electroless nickel, 3-5 micro-inches of immersion gold
  - Fabrication Process 2 weeks
  - Fit 25-30 antennas on one sheet for $350

Information from Cunningham Graphics

- Working on Gerber File
  - 10 designs cost about $850
  - 7 designs cost about $650
  - 4 designs cost about $450
- Four designs Chosen
  - Coplanar Waveguide by itself
  - Radiating part θ = 45, 60, and 75 degrees

Information from Cunningham Graphics



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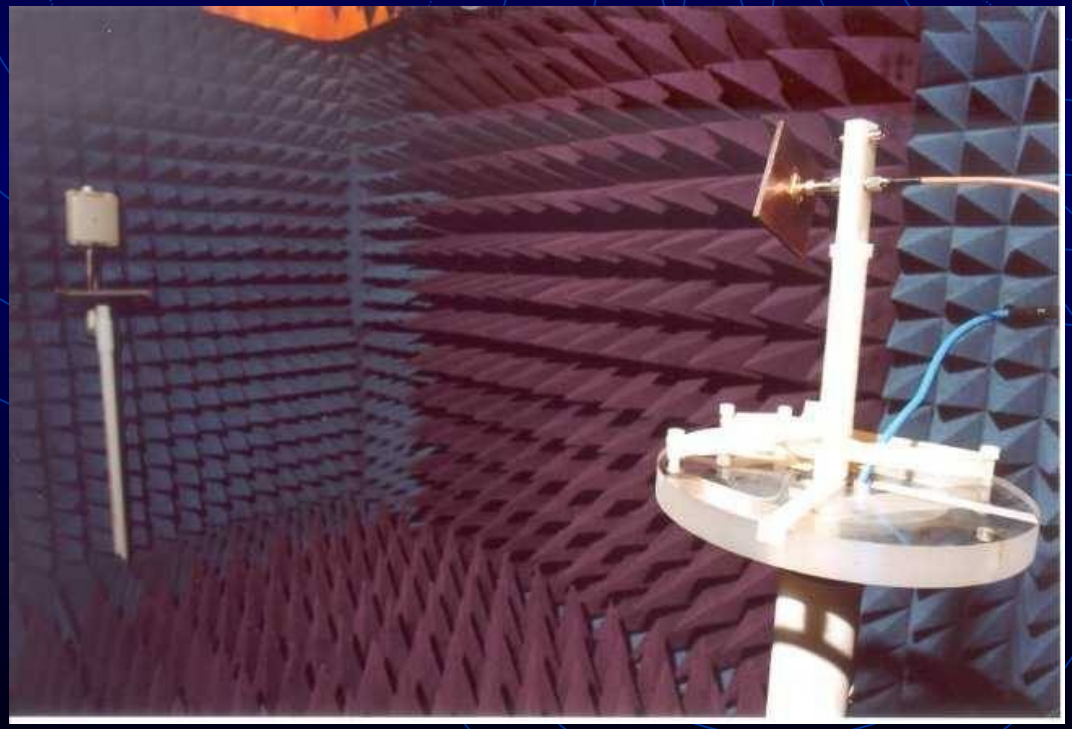
Equipment List

- Network analyzer - HP8722C or HP8410C
- Agilent Advanced Design System - ADS
- Pulse Generator – HP8011A (Possibility the Signal Generator)

Some Pictures of the Equipment

Anechoic Chamber

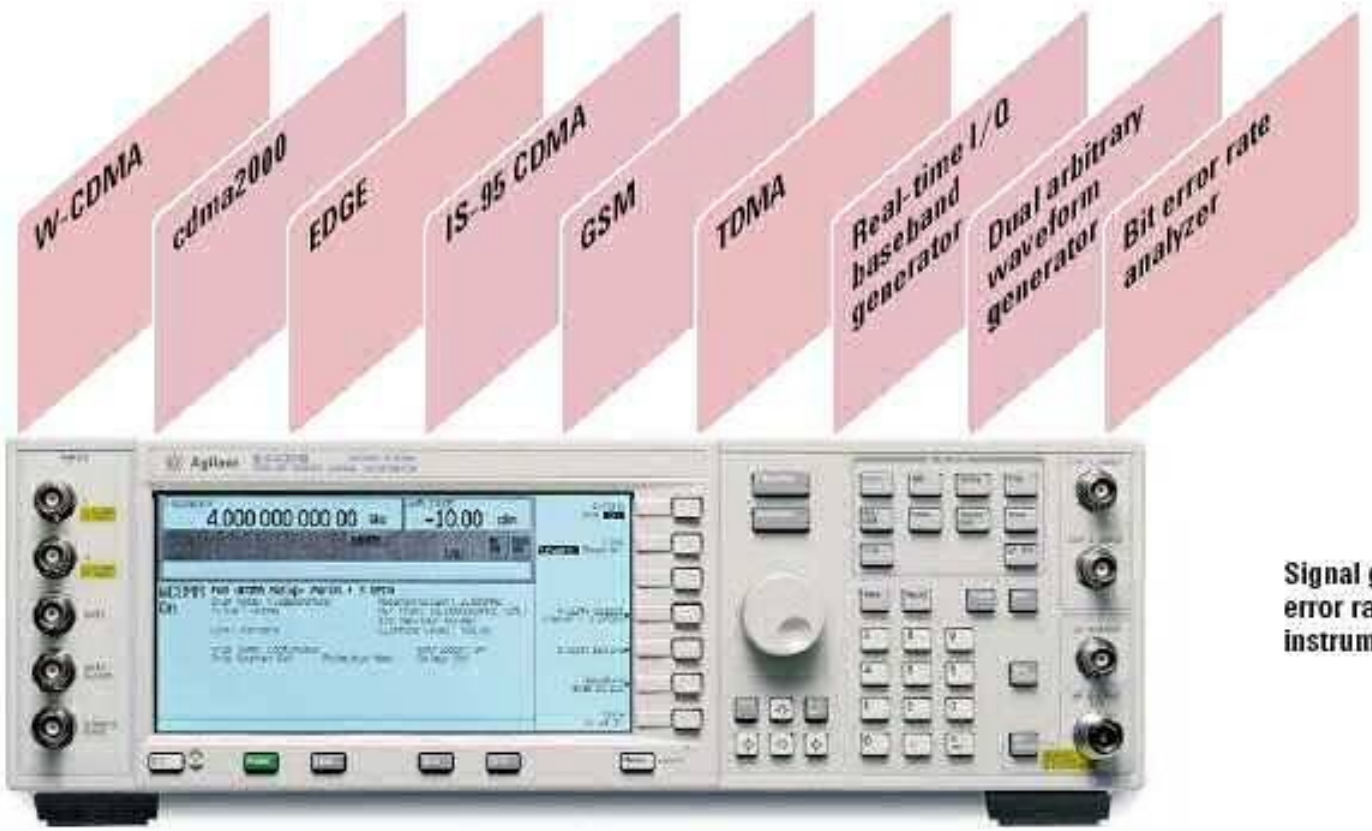


Some Pictures of the Equipment

Spectrum analyzer - HP8593E or HP8559A

Some Pictures of Equipment

Signal generator - HPE4433B (May be used instead of Pulse Generator)



Signal generation and bit error rate analysis in one instrument.

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EE 409 (RF Comm Lab) Labs

- Network Analyzer
- ADS Lab

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Goals and Completion of Goals

- To have a working antenna
  - About 85-90% complete
  - Simulation working
  - Stuck at fabrication
  - VSWR less than 2
  - Works over UWB frequency range
- Increase knowledge on Antennas
  - Transmitting and Receiving antenna
  - One port system
- Increase knowledge on UWB
  - Pulse based not frequency based

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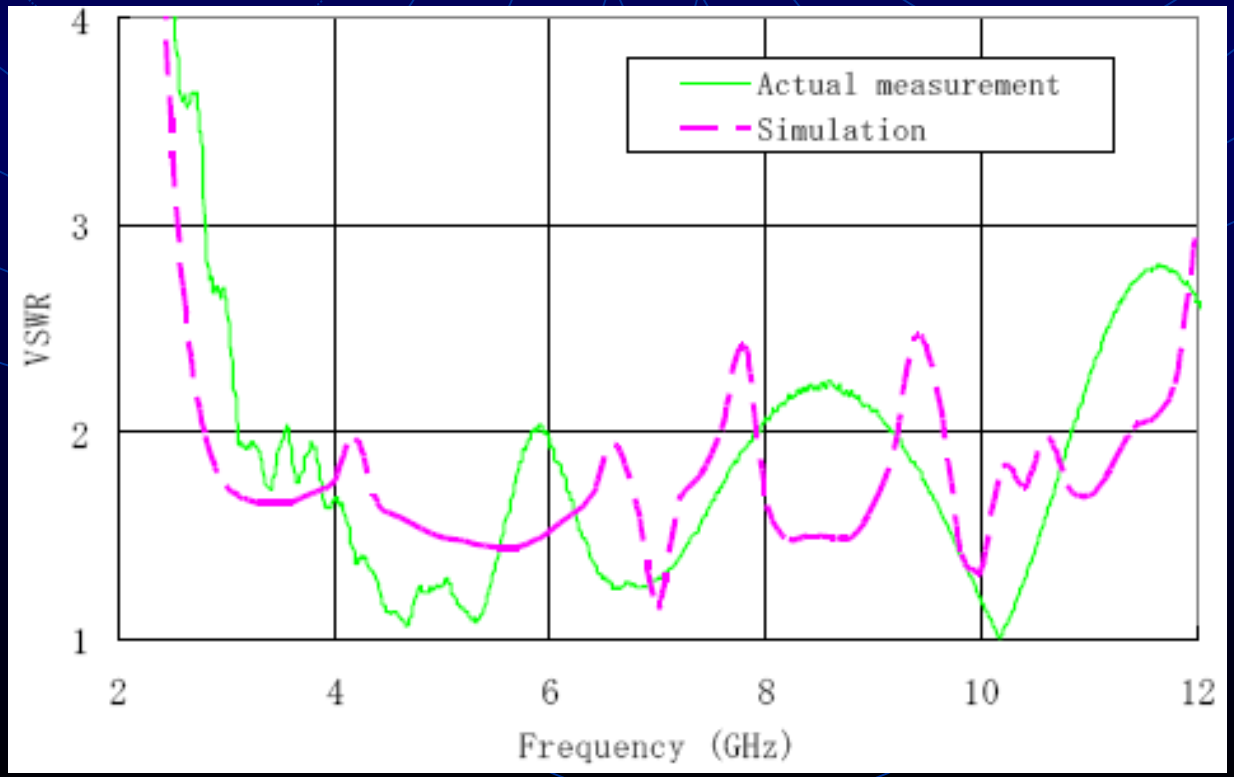
Future Work

- Test designs coming back from Cunningham Graphics
  - Would like to do it myself
- Have all 10 designs of the UWB Antenna be fabricated and tested
- Use Sonnet to test radiating part of the antenna
- Change via holes' positions
  - Have them be a least 3 times the gap from the edge of the side planes -- requested by an advisory board member

Future Work

- Expected VSWR characteristics (from reference antenna)



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Special Thanks

- Special thanks to Bob Modica (Cunningham Graphics)
- Suresh Sundaram (Validus) and Bala Sundaram (Validus)
- Divya Gamini (Grad Student)
- Saif Anwar and Sarah Kief – helping with ADS

- Dr. Prasad Shastry (ECE professor and advisor)

Paging Dr. Ahn, you have a phone call on the white curtsey phone. Please answer right away.

Questions ?

- I’m sorry; you did not answer in the form of a question.