SAR Imager

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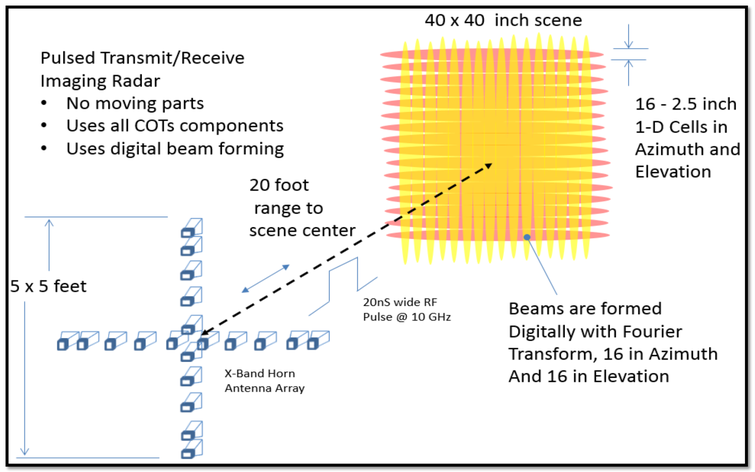
Design Concept

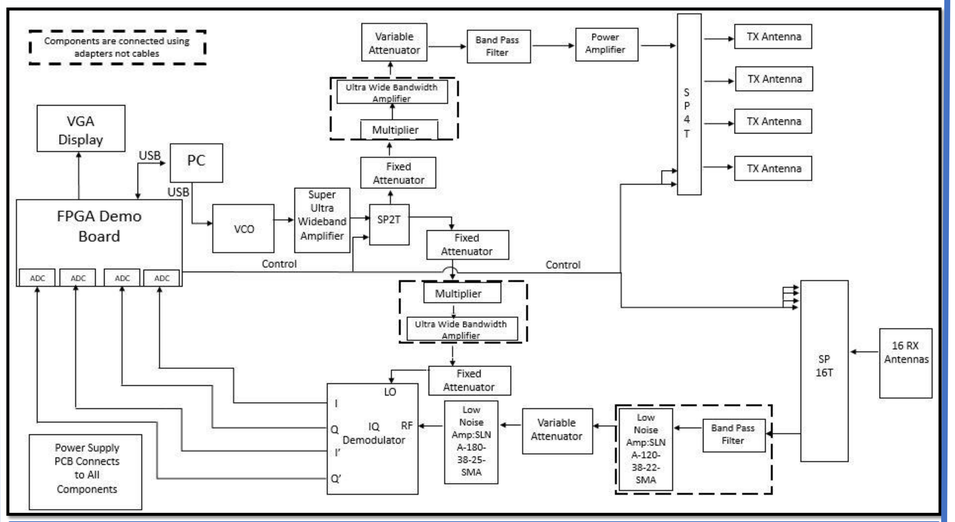
– 20 Antennas: 16 Receive – 4 Transmit
– Controls: FPGA - Signal Processing, Timing, A/D Conversion, and Image Generation
– Structure: 2 Rows of 10 Antennas – Orthogonally Placed, Target Epicenter in Middle of 2 Rows



Requirement	Units	Value	Comments
Frequency	GHz	10.0 +/- 0.1 GHz	Single frequency operation. BW supports 1/PW
Down range resolution	inches	N/A	A future enhancement to performance
TX Pulse Width (PW)	nS	20	
Transmit Power	W	0.2	
Antenna aperture size	feet	5 x 5	Waveguide horns in cross configuration
Pulse Repetition Interval	nS	100	
Receiver Noise Figure	dB	3	Does not include front end losses

What is an SAR?

– *Synthetic Aperture Radar:* Electronically synthesizes high resolution performance of very large antennas from smaller antennas, captures several high resolution images to create single image map.
–*Typical Use:* Environmental Monitoring, Earth-Resource Mapping, and Military Applications
–*Project Theory:* 20 stationary antennas, creating a single low resolution image for the purpose of detecting metal objects and weapons
–*Typical Use:* Gov't Buildings, Schools, Airports, & etc.

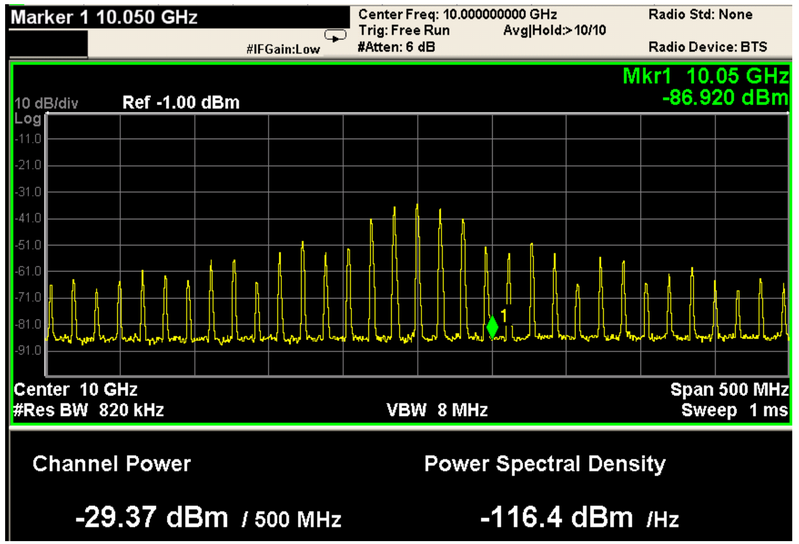


Electrical System Chain Overview

– *Transmit*: Generate RF Pulse 20 ns
– *Receive*: Reflected RF signal scatterings from target
– *IQ Demodulator*: Convert the phase and amplitude of the received RF scatterings to DC voltages

Sample Testing Results

Components	Measured Power	
	dBm	mW
VCO	-4	0.398
Super Ultra Wideband Amplifier	20.9	123.027
SPDT Switch	19.76	94.624
Frequency Multiplier	-3.06	0.494
Ultra Wide Bandwidth	8.94	7.834
Power Amplifier	22.5	177.828
SP4T Switch	20.38	109.144



– SP4T Signal Output measured Spectrum Analyzer
– Shows the pulse width (20ns) of the signal in frequency domain centered at 10 GHz.
– The null frequency is the pulse width.

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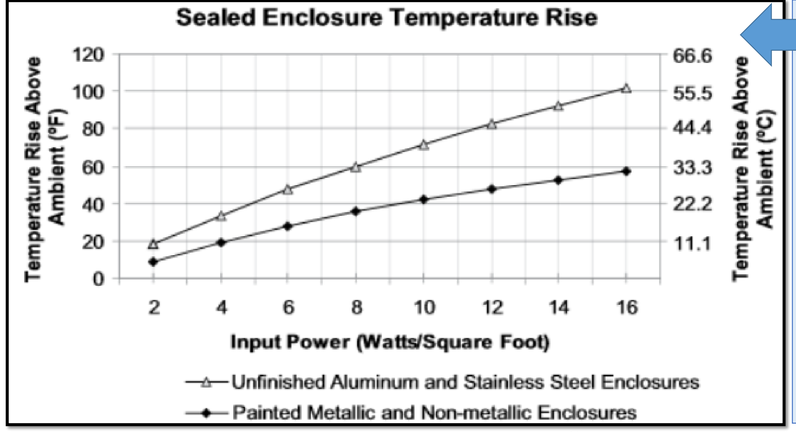
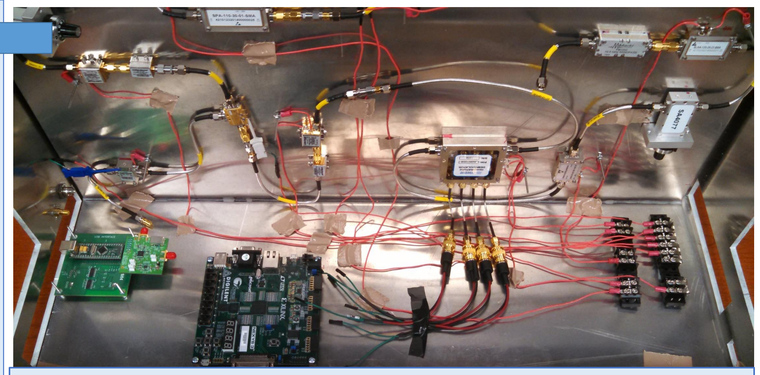
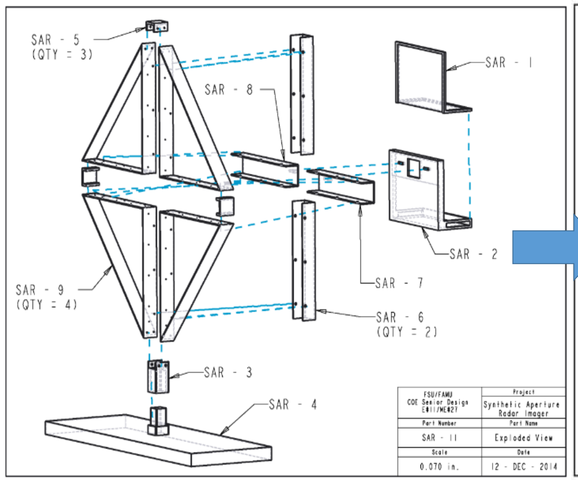


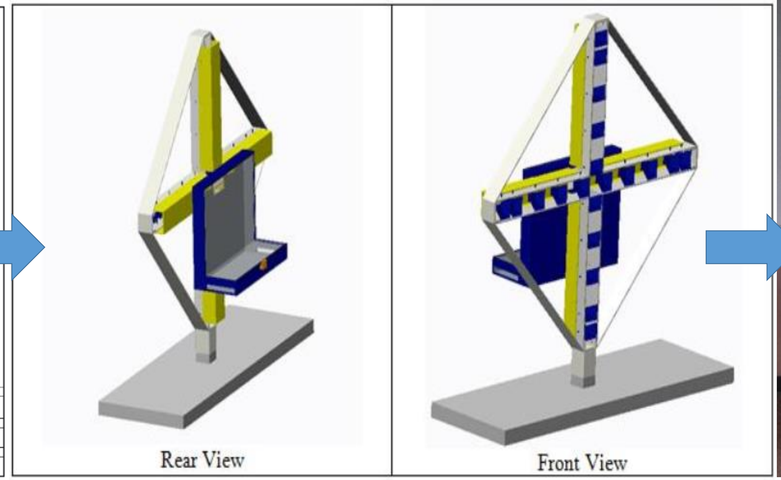
Component Box Heat Transfer

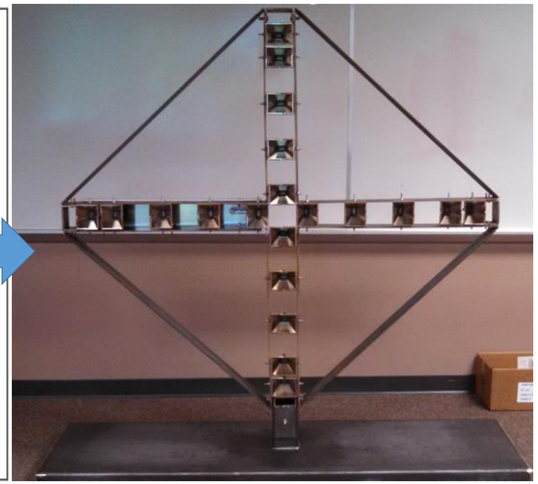
- Box Surface Area: 12.76 ft^2
- Power Supplied: 34.8 W
- Heat Flux: 2.7 W/ft^2
- Temperature Rise: 13.5° ± 2.8°



Component Box with Electronics

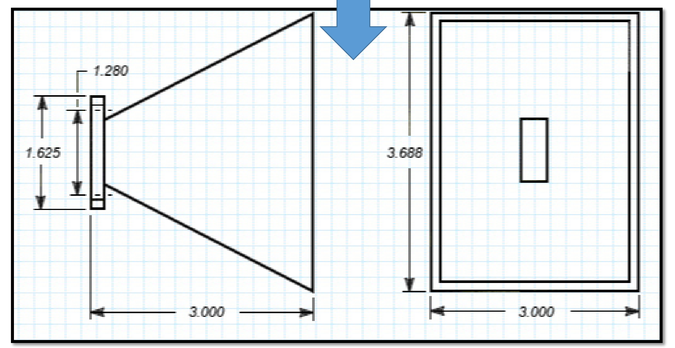






Antenna Horn Specifications

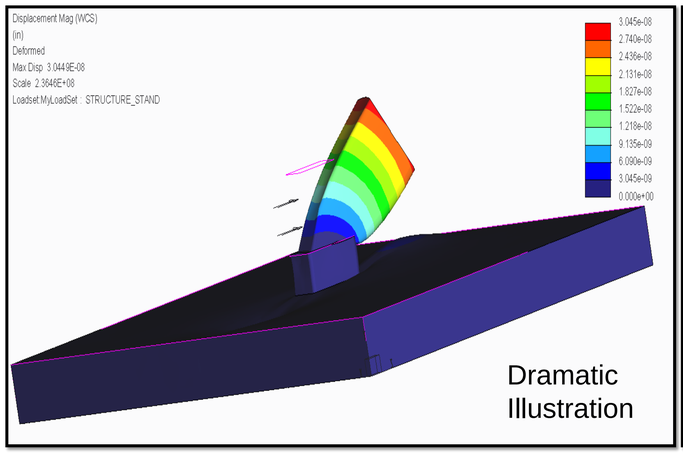
- Frequency Range: 8-12.4 GHz
- Nominal Gain: 17 dBi
- Scene Extent: 9’ x 9’



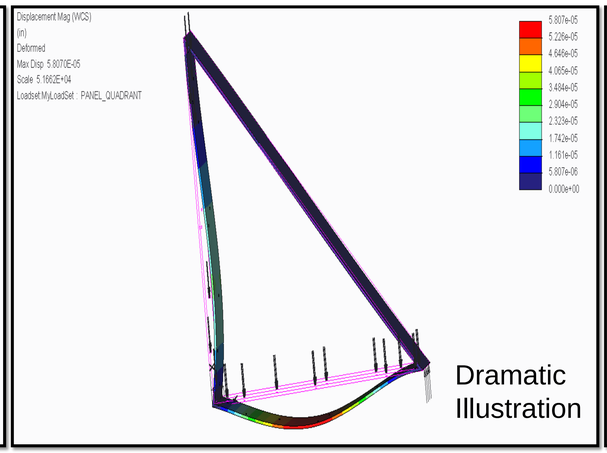
CAD Drawing: exploded view of component placement for Antenna Structure

3D Rendering: Rear and Front View with attached component box and yellow horn covers in place

Actual Model: 4 Quadrant Panels Welded, Horns Installed, and mounted on stand



Dramatic Illustration



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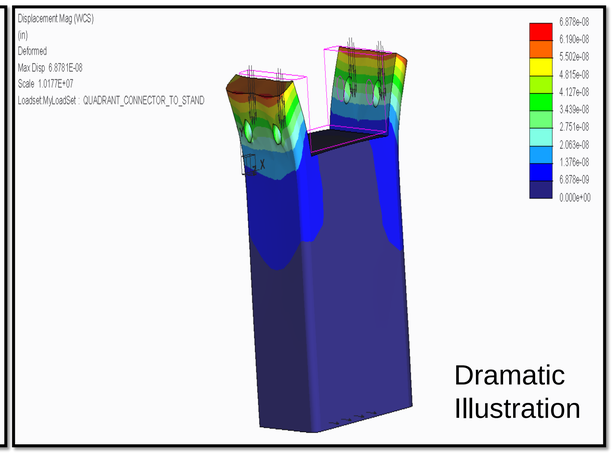
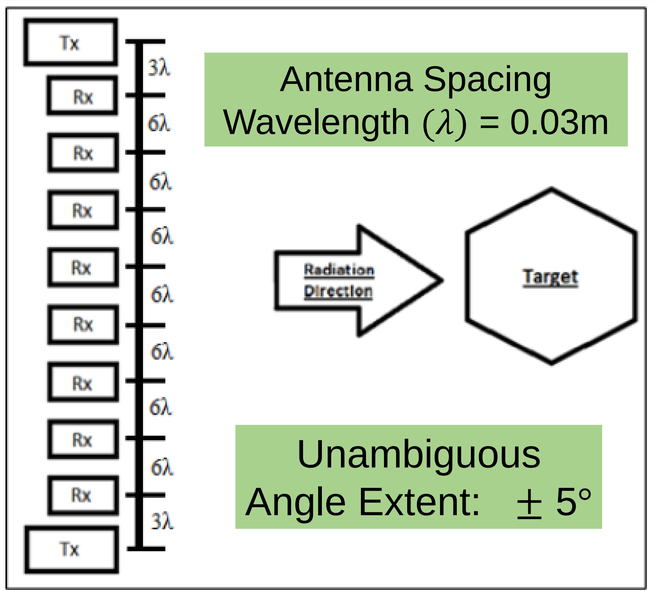


Dramatic Illustration

- **Steel Frame Stress Analysis**: Design specifications indicate that there will be no major deformation under the loads.
- **Max Displacement:** Stand 3.044×10^{-8} in (130 lb), Quadrant Panel 8.506×10^{-5}in (70 lb) C-Channel 6.878×10^{-8} (130 lb)



Antenna Spacing Wavelength (λ) = 0.03m

Unambiguous Angle Extent: ± 5°

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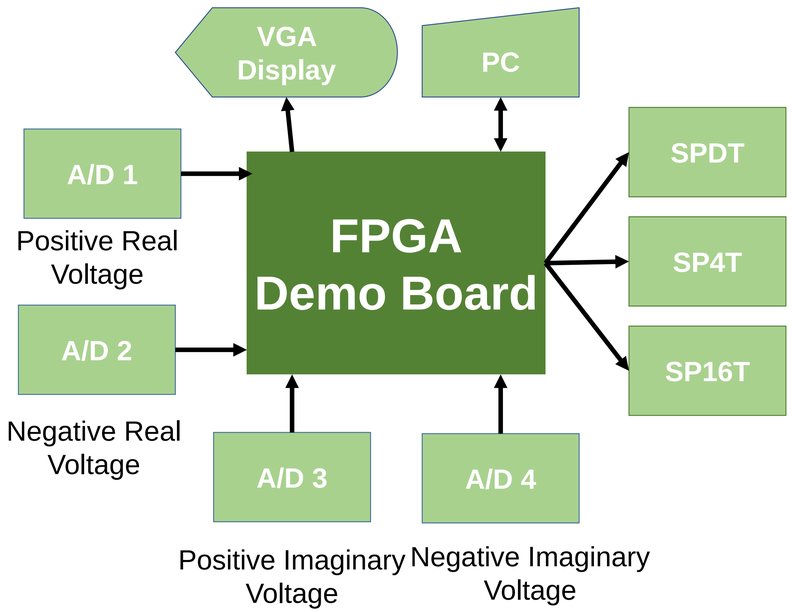
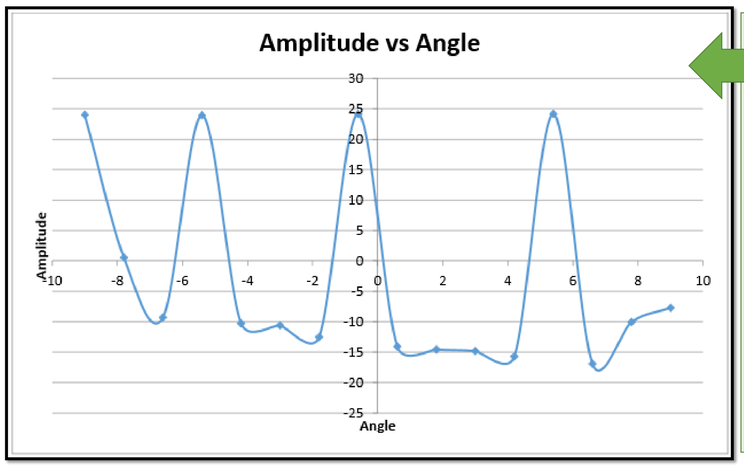
VHDL Coding Subtasks

Discrete Timing Control	A/D Conversion	VGA Code
• Switch Timing • Controls between Transmit/Receive Mode	• IQ Demodulator voltage logic stored in 12-bit word • Range: 0-3.3V	• Metal highlighted in 1-D 16 column display



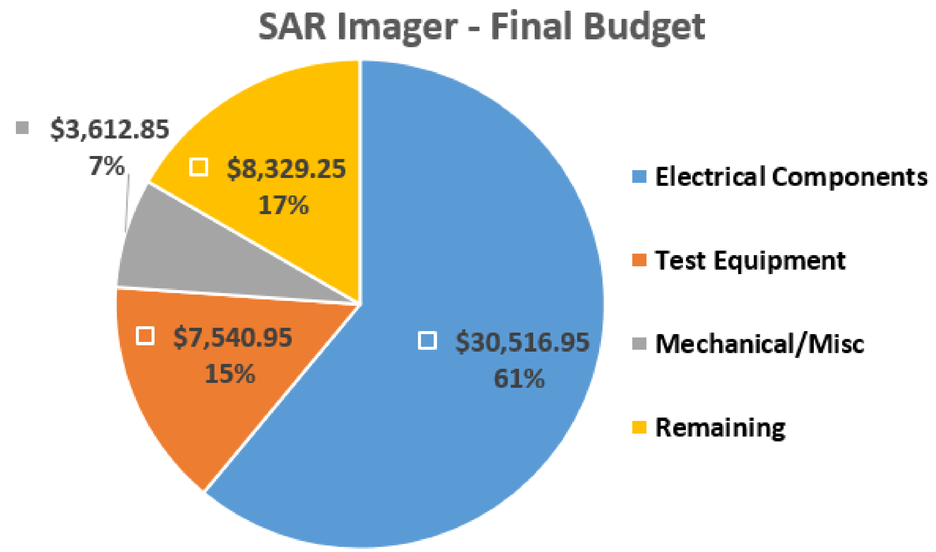


Signal Processing

- 1D image representing incoming energy at 3 different angles
- Display would have 4 "strikes" indicating incoming energy

Multidiscipline Project Division

Electrical	Mechanical	Industrial
• Radio Frequency • Signal Processing • FPGA Programming • Antenna Aperture • Procedure & Testing	• Antenna Structure • Component Box • Trihedral Design • Structural Analysis • Build & Assembly	• Proj. Management • Budget Allocation • Procurement • Risk Analysis • Webpage Design



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Future Recommendations

Electrical	Mechanical	Industrial
• Practice Soldering & Learn Advance Testing Equipment Methodology • Develop Formal Testing Procedure • Create an Operating Manual • Advance Signal Processing Code on FPGA and Display	• Increase Rigidity of Structure • Perform In Depth Thermal Analysis on Electrical Components • Add Wheels to Structure for Ease of Mobility	• Perform DFMA Analysis • Formalize Procurement Procedure • Perform Reliability Study & Improve System