PARAMETRIC TEST OF DIRECTION OF ARRIVAL ESTIMATION USING FPGA'S

CHARLES 'C.J' WILLIAMS (OKLAHOMA STATE UNIVERSITY)
ADVISOR: DR. BROCK J. LAMERES

ELECTRICAL & COMPUTER ENGINEERING DEPARTMENT
MONTANA STATE UNIVERSITY, BOZEMAN, MT REU 2010 PROGRAM

2010 Montana State University Summer Undergraduate Research Program

Background

Montana State University is developing a Smart Antenna to increase the reliability of military communication systems. The project began using a fully analog system. The disadvantages of an analog approach are:

(1) Cost
(2) Size
(3) Low resolution
(4) Inability to perform complex algorithms for DOA/beam forming.

MSU is implementing a fully digital Smart Antenna System to address these concerns.

Project Objectives

This project was defined by Montana State University: Electrical and Computer Engineering Department. The design objectives were defined as follows:

Task#1: Perform parametric testing on fully digital direction of arrival algorithms while varying the:

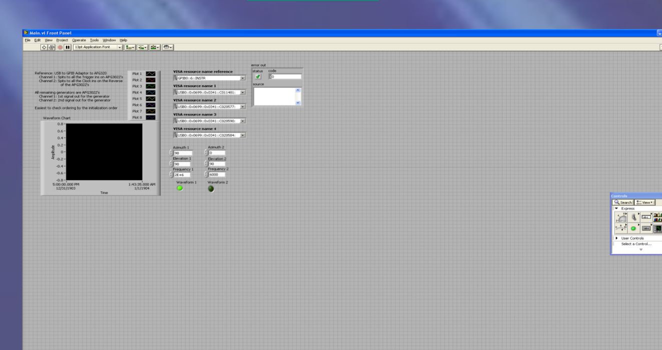
- •Algorithm (Bartlett and MVDR)
- •Angle of Arrival(1-360 degrees)
- •Single versus multiple beams
- •Signal to noise ratio

Task#2:Evaluate accuracy of FFT/IFFT when varying number of bits in the fixed point operation.

System Overview


Analog to digital Converter

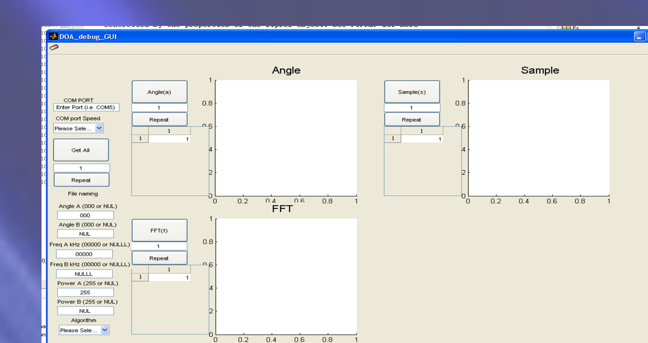

Function Generators


Lab-view GUI

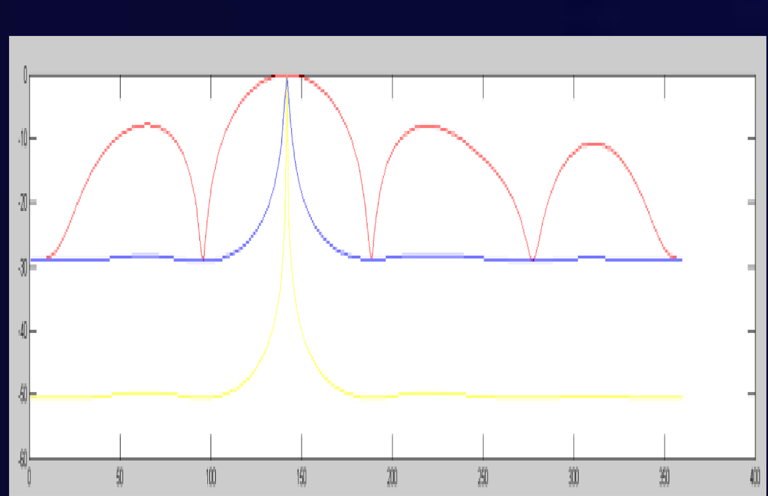
User Interface:

- Uses 4 Function Generators to read in angle from FPGA.
- Set Angle on FPGA
- Set Frequency
- Set Power


FPGA BOARD

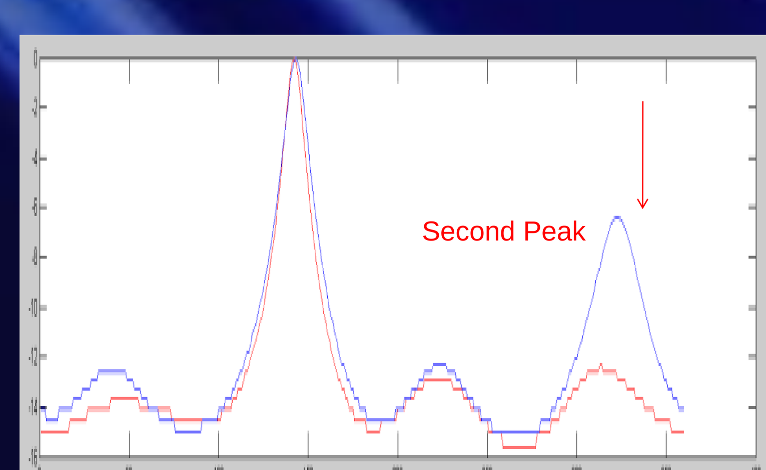

DOA GUI

Results

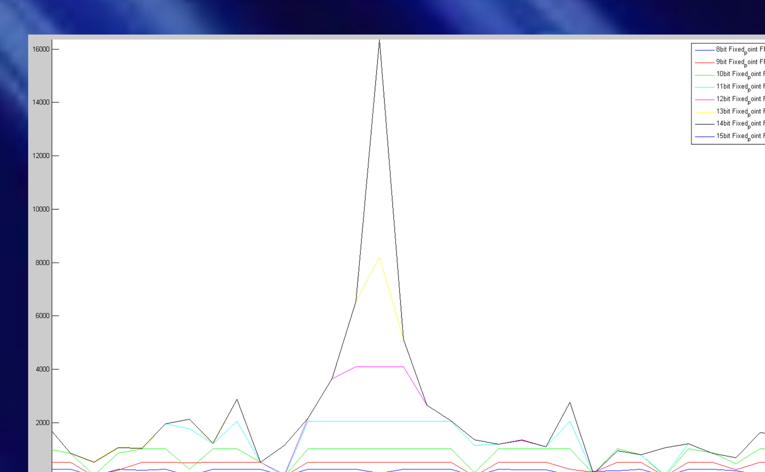


•The red lined graph is Bartlett algorithm in dB.
•The blue lined graph is Capone algorithm in dB.
•The yellow lined graph is Music algorithm in dB.

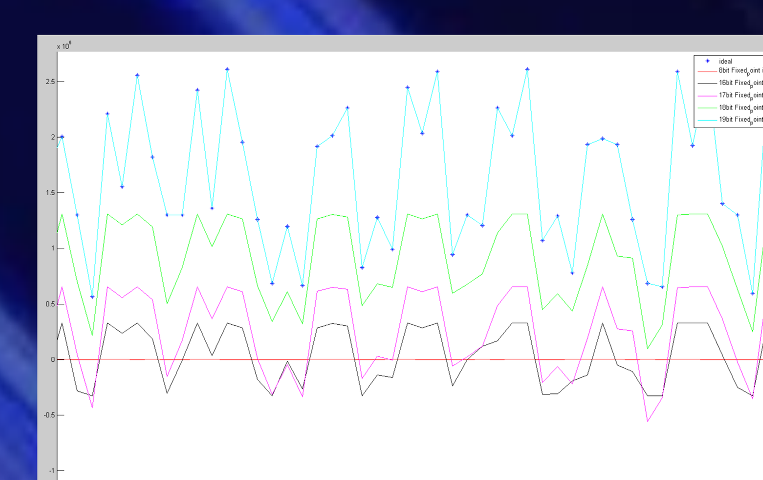
The 3 algorithms were graph from 1-360 degrees to show what a perfect DOA would display.



The image above illustrates measurements from 1-360 deg using an FPGA based DOA. The red line is the Bartlett DOA algorithm. The blue line is the MVDR DOA algorithm. With this information, we were able to see that the algorithm implementations had error. It was determined that the error occurred in the hardware implementations of the Hilbert transform.



The figure above illustrates a 1024 point Fast Fourier Transform. Varying the precision (i.e number of bits) in the computation. The purpose of this experiment was to see the minimum amount of bits necessary for an FFT without losing accuracy. It was determined that a 16 bit FFT was sufficient.



The figure above illustrates a 1024 point Inverse Fast Fourier Transform. Varying the precision (i.e number of bits) in the computation. The purpose of this experiment was to see the minimum amount of bits necessary for an IFFT without losing accuracy. It was determined that a 19 bit IFFT was sufficient.

Conclusions

In this project, I performed parametric testing on an FPGA-Based direction of arrival system(DOA) that is part of a smart antenna system that is being developed at Montana State University. The Smart Antenna system is designed to detect the spatial location of users and form directional beams corresponding to their location. This allows the system to increase the power of the communication link to provide higher quality data transmission.

Future Work

- •Finish MVDR algorithm
- •Hilbert Transform
- •Test in the Anechoic Chamber

Acknowledgments

This work is supported by the National Science Foundation Research Experience for Undergraduates (REU) program under grant # EEC-100257

Mentor: Brock J LaMeres

Student Mentor: Sam Harkness

Advisors: Richard Wolff and Yikun Huang