Small Rotor-Craft Obstacle Avoidance Imaging Radar

Team sdmay21-07 Members: Felipe Varela Carvalho, Matthew Bahr, Matthew McDermott, Leonardo Bertoncello Machado, Michael Ostrow, Joshua Welton
Advisor: Dr. Al Qaseer

Problem Statement

- Overhead power lines present danger to flying rotor-craft and collisions could create danger for infrastructure and people
- Locating these dangers through traditional methods is very difficult

Solution

- Create a proof-of-concept prototype radar system to spot hazardous objects

Users

- Anyone who would pilot any type of air rotor craft such as drones or helicopters
- Self-piloting drones assessing object orientation

Uses

- Will help spot objects that the pilot may not be able to see normally. Will alert pilot of location to prevent a collision

Hardware Testing

- Antenna was connected to Vector Network Analyzer to simulate antenna array to test detection capabilities
- ADC PCB was connected to Raspberry Pi and function generator to simulate differential input signals

Software Testing

- Antenna simulations to get ideal outputs before fabrication (CST studio)
- Matlab simulation of data
- Processed Vector Network Analyzer antenna data in MATLAB

Results

- Manufactured antenna met minimum requirements
- In a controlled environment, we were able to detect a wire and its angle at a short distance from the antenna
- Raspberry Pi was able to collect data from ADC PCB, but data received was incorrect

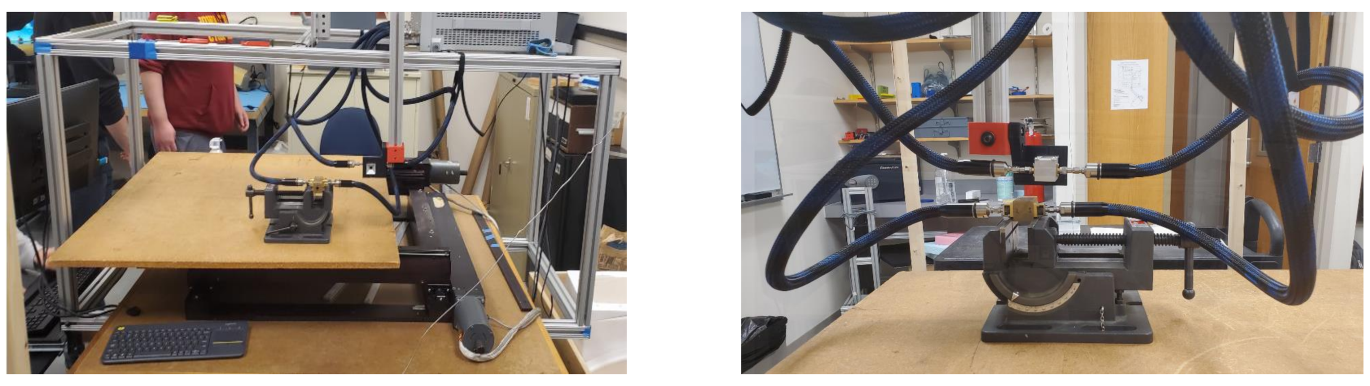

Figure 1. Antenna Testing

Functional Requirements

- Utilize multiple antennas to detect a distant object and the object's size and orientation
- Detect objects in the range of 10 –100 meters
- Create a visual overlay of obstacles for a pilot to view

Non-Functional Requirements

- Transmit and receive data from antennas through PCBs
- Integration between PCBs and computer software
- Computer software visually recreates what the antenna detects in a new manner suitable for an operator to interpret

Constraints

- Fabrication limitations for PCB and antenna
- Noise interference and leakage from SMA connectors
- Frequency range due to licensing consideration

Operating Environment

- System will function in low visibility and mild weather – e.g., fog, mist, dust

Standards

- **IEEE 145**: Established definitions for systems incorporating antennas into their design.
- **IEEE 370**: Practices for ensuring the quality of measured data for high-frequency electrical interconnect

Functional Details

- Horn Antenna that operates at a range 23.5 – 24.5 GHz
- RF Circuit with precise frequency control
- 24-24.25 GHz Spectral Sweep
- 100 kHz ADC w/ 16b Resolution
- MCU w/ SPI and Serial Capabilities
- PC for signal processing using Python

Iowa State Resources

- ETG Shop
- CST Studio
- Vector Network Analyzer
- MATLAB / Python
- Altium

External Resources

- JLCPCB
- Digi-Key

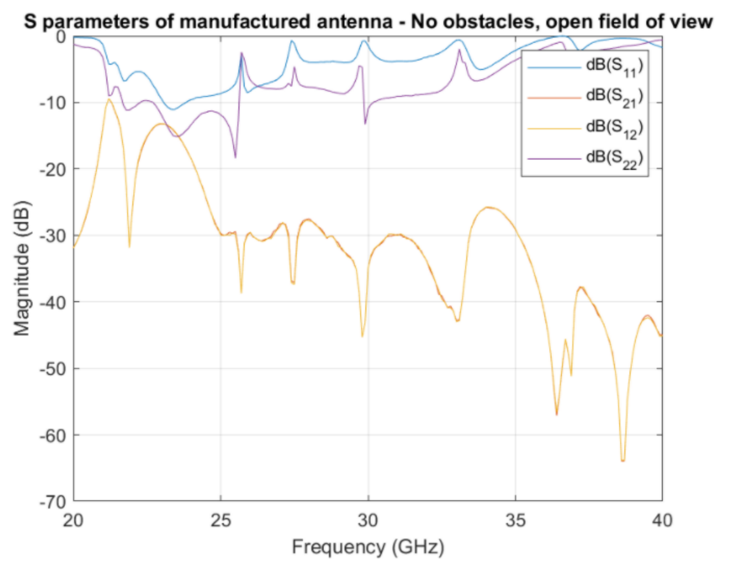

Figure 2. S-Parameters

Design Approach

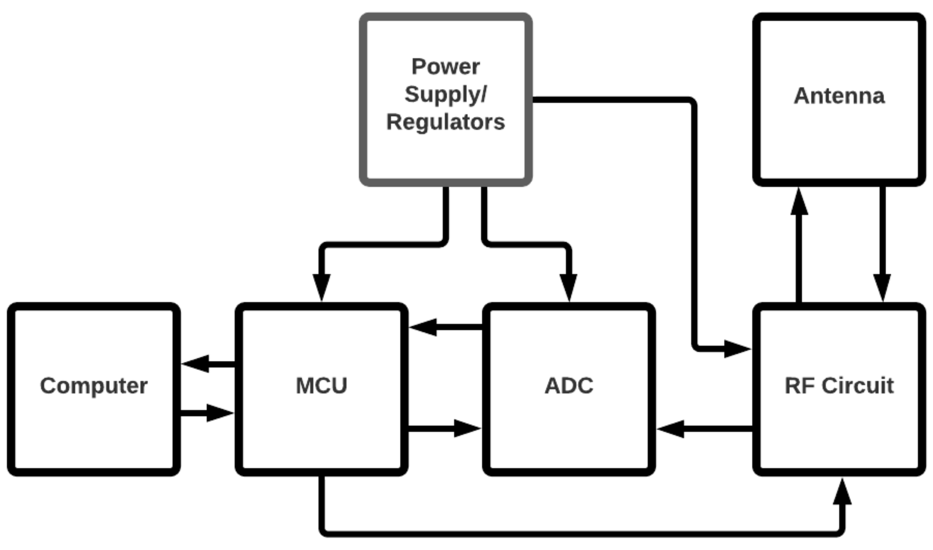

Figure 3. Block Diagram

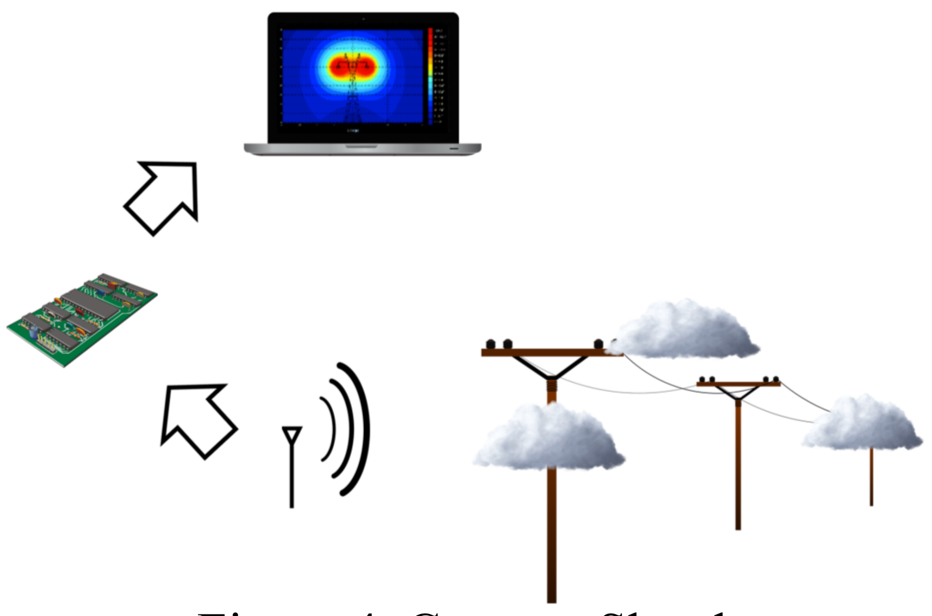

Figure 4. Concept Sketch

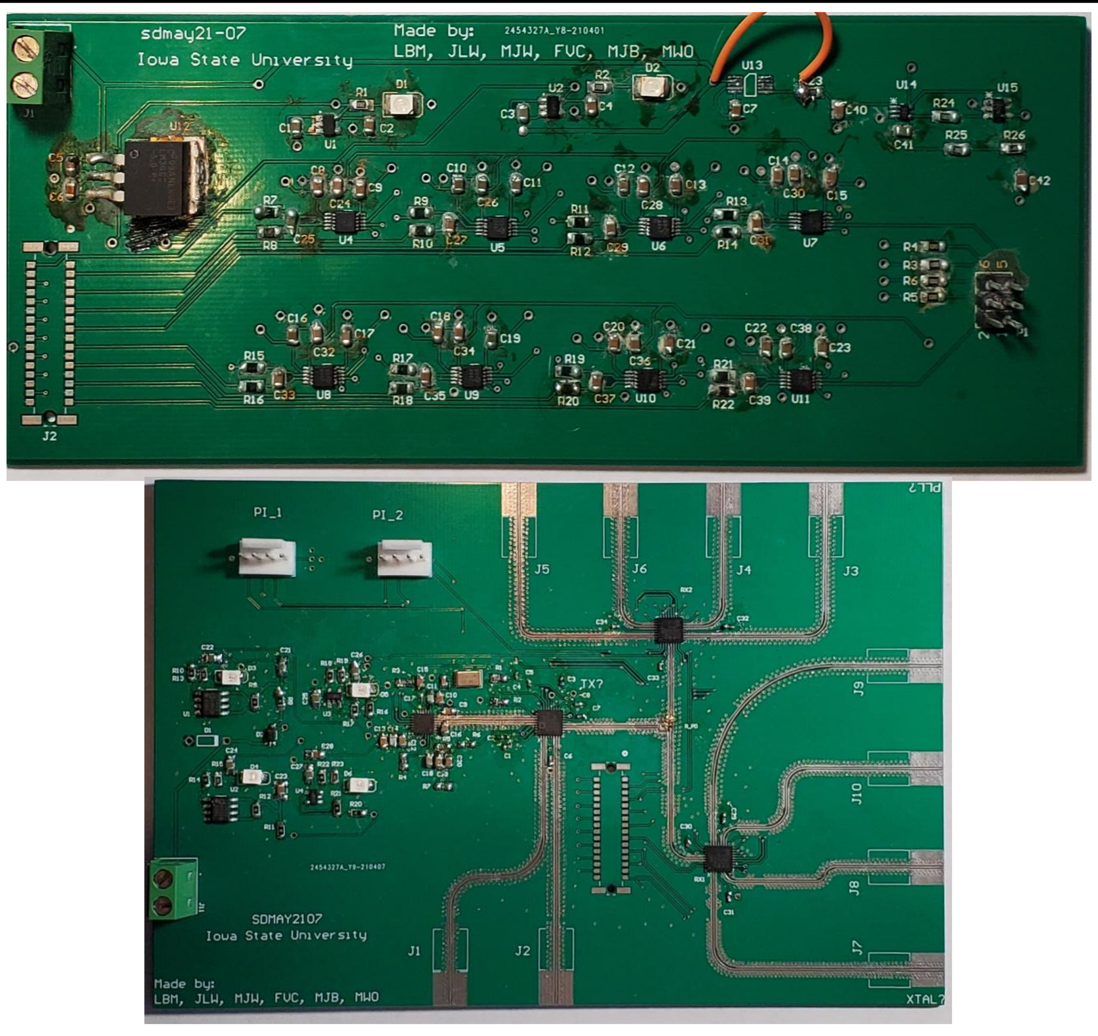

Figure 5. ADC & RF PCB

Functional Modules

- Voltage Regulators control voltage and current output to circuit elements
- Radio frequency (RF) circuit sends out and receives a signal through the antenna, sending data to both the microcontroller and ADC board
- Antennas emit (1) and receive (4) signals being output by RF circuit, creating circular polarity to the signal for ease of data processing
- Analog-to-Digital converters (ADC) convert data into a binary serial format, sending information to the microcontroller
- Microcontroller takes and packages data to be sent to the computer, as well as regulate functions for the RF circuit
- Computer processes data and generates an image overlay to display the obstacles