FPGA Enhanced Digital Beamsteering Phased Array

Team 311
Sponsor: L3Harris
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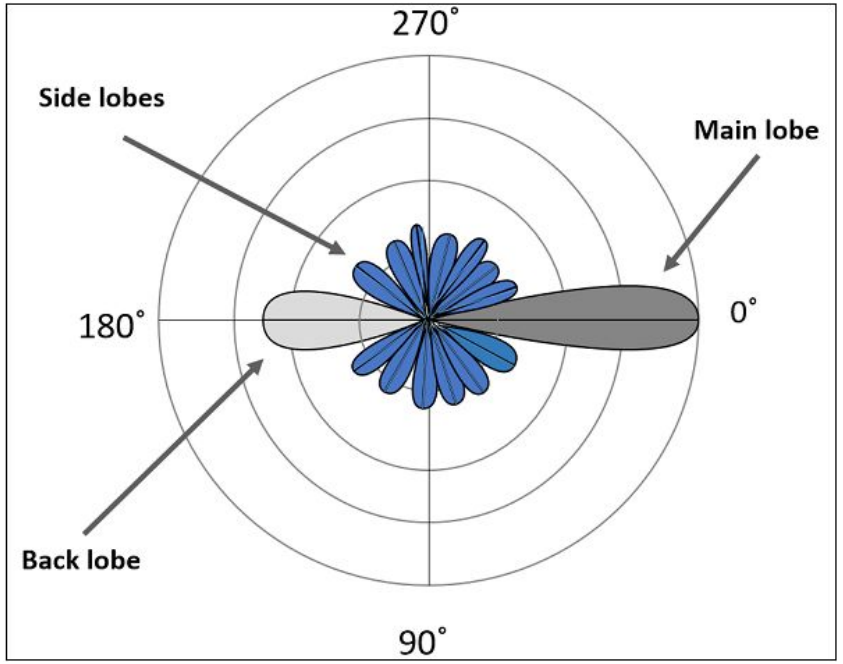
Outline

- Project Background
- Project Scope
- Customer Needs
- Requirements
- Materials
- Project Approach/Plan
- Functional Decomposition
- Summary

Project Background

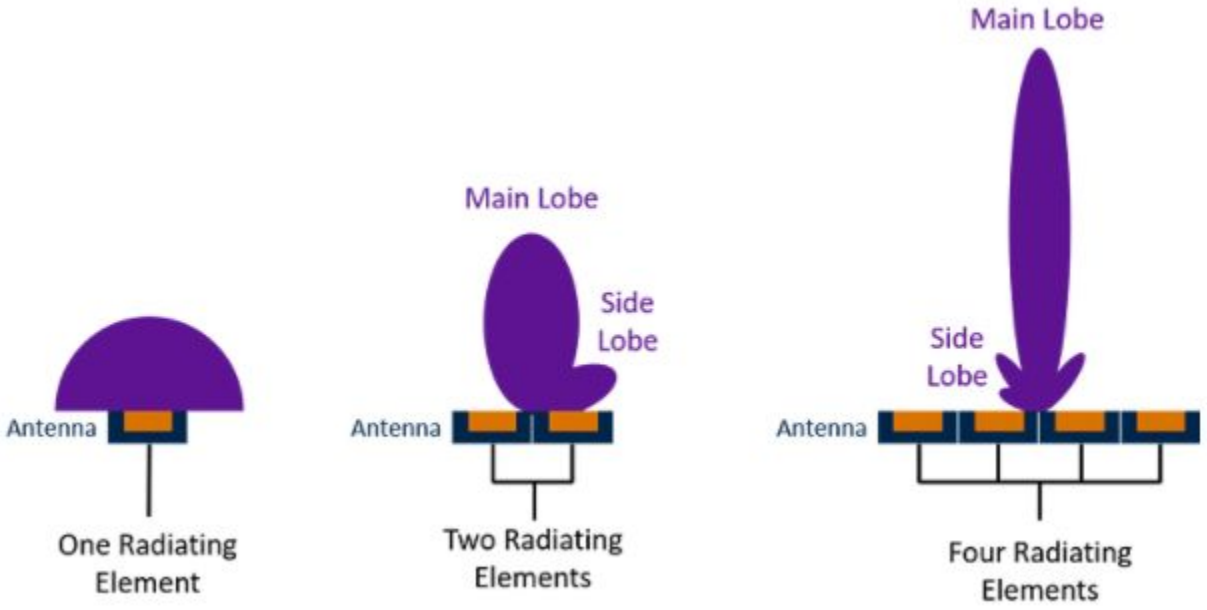
What is an antenna?



- An antenna is a radiating element.
- Emits electromagnetic radiation
- Parts of an antenna radiation pattern:
  - Main lobe, side lobes, and back lobes

Project Background cont.

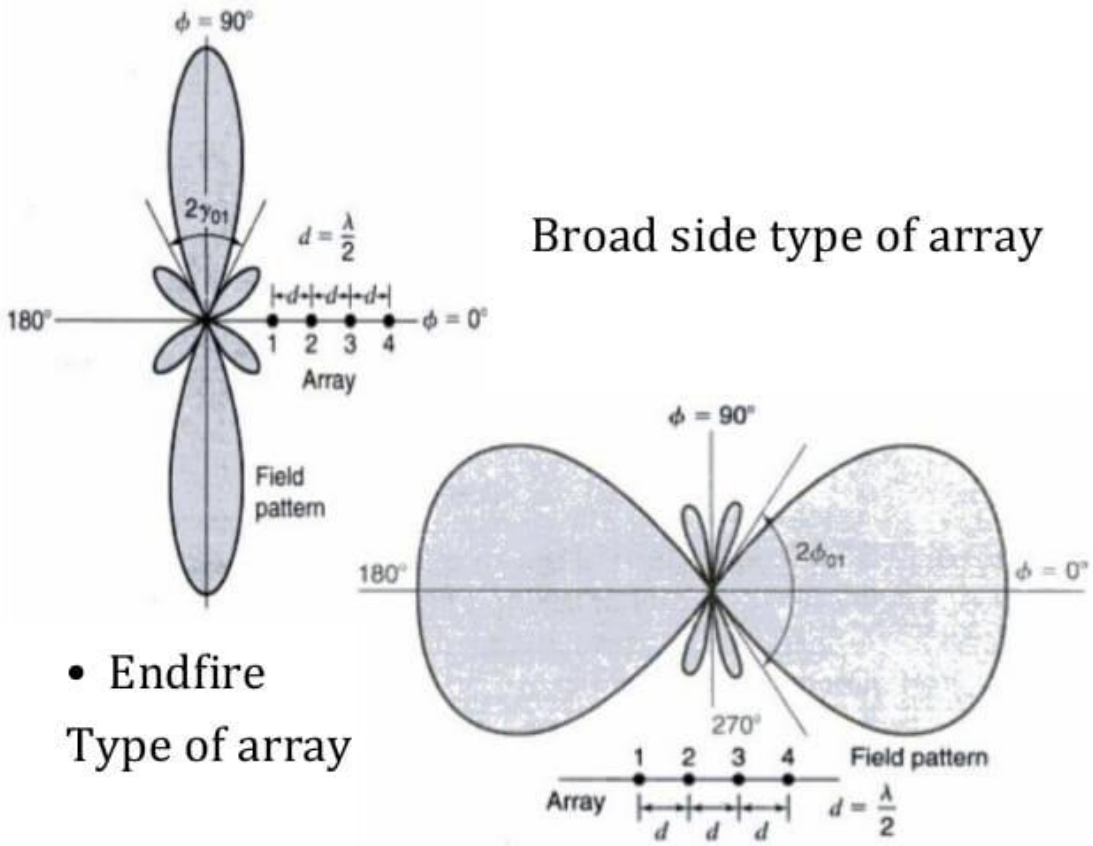
Why use an antenna array?



Project Background cont.

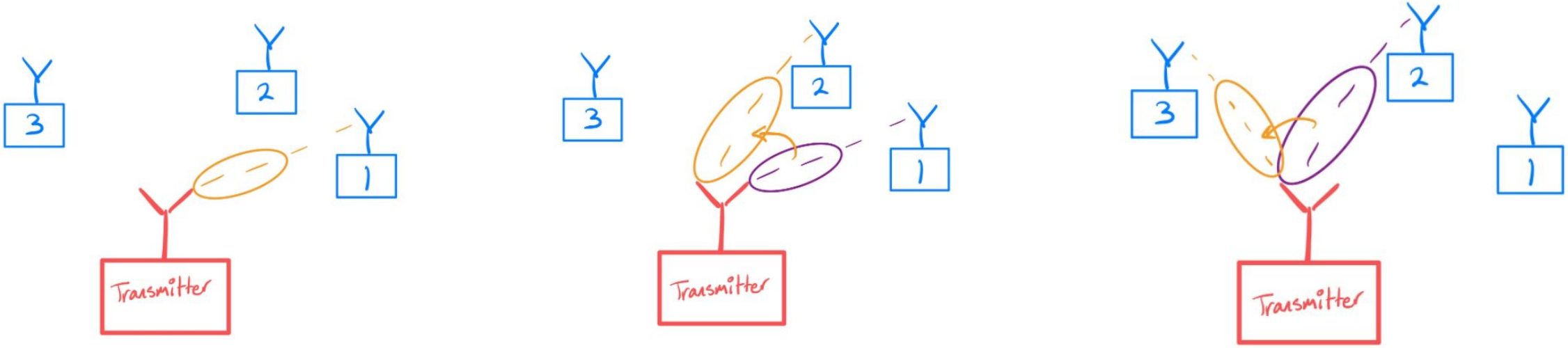
Types of antenna arrays

What type of antenna array does beamsteering use?



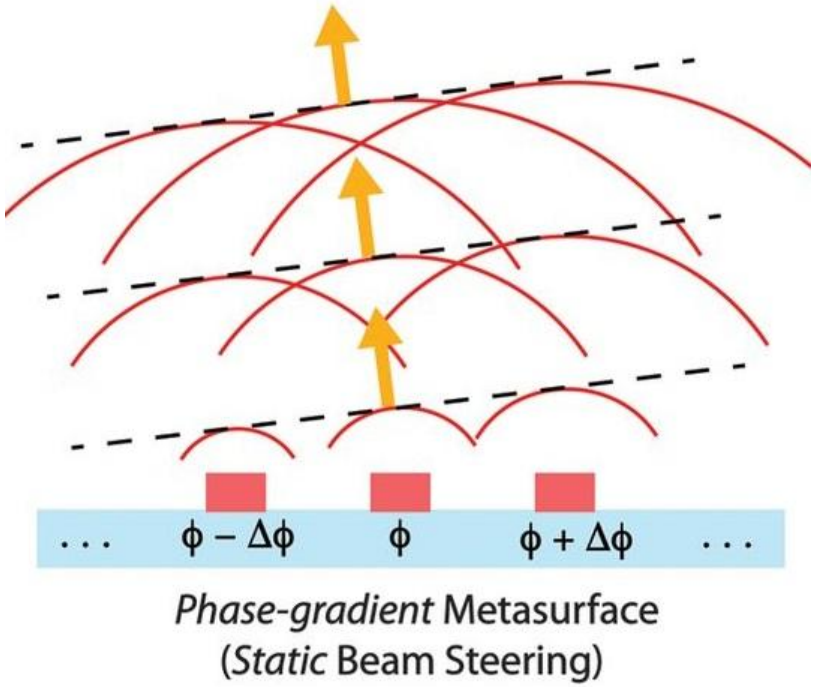
Project Background cont.

Basic goal of beam steering



Project Background cont.

How does beamsteering work?



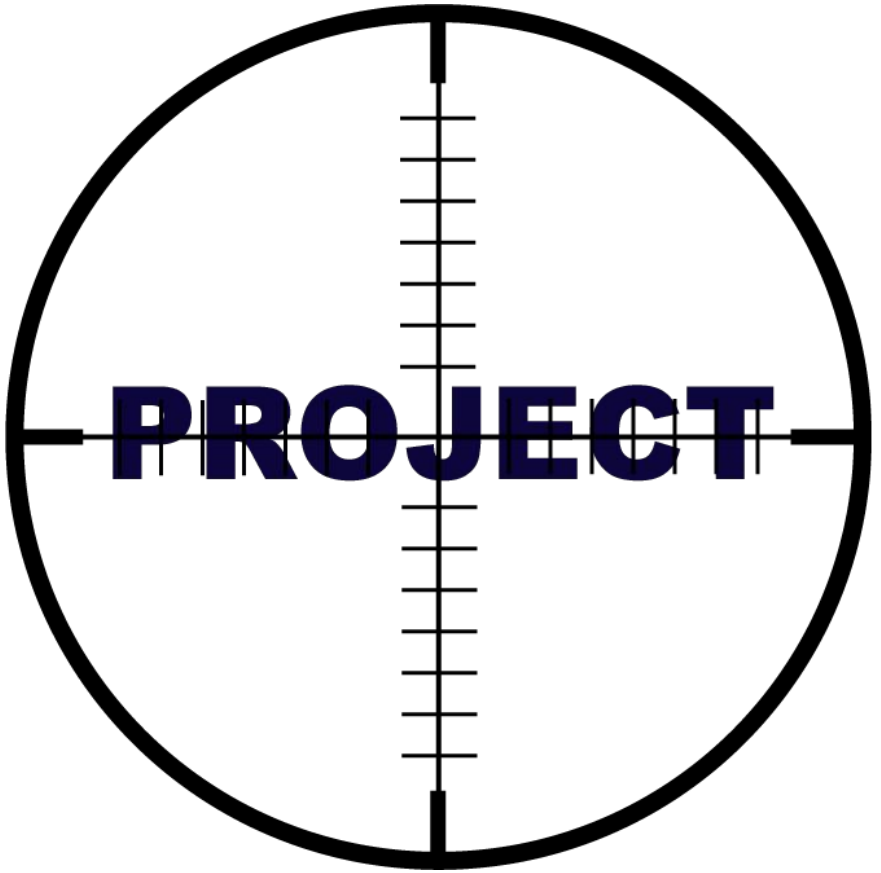
Project Scope

Project description
FPGA controlled transmitting phased array.

Key Goal
Control a digital signal to control the radiation direction of the array.

Market
Radar, sonar, wireless communication

Assumption
Transmitter will operate in the ISM band with <30 dBm output power
Array will be linear and consist of four antennas

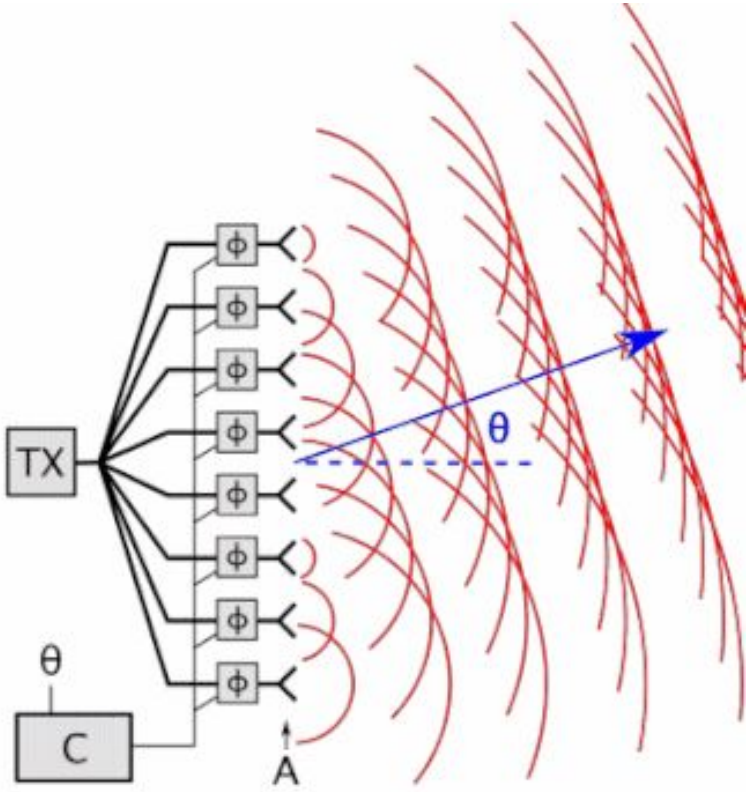


Customer Needs

- FPGA/MCU Controlled
- Steer the direction of radiation (Beam-Steering)
- More Efficient Long Range Transmitting Device
    - Beam Steering can extend communication range
    - Waves are easily blocked and weaken over long distances.
    - Multiple beams can be created and focus in on multiple objects at the same time.

Requirements

- Algorithm to control and maintain the optimum radiation beam position
- Operating Frequency within ISM Band
- 4 Channel DDS/Antenna Array
- Measure Phase Difference and dB Gain



Materials

- 4-Channel Antenna Array
- Mixer
- Digital to Analog/Analog to Digital Converter
- FPGA/MCU
- Direct Digital Synthesis
- RF Up-Converter

Project Approach

Given our open ended approach, we have a lot to consider:

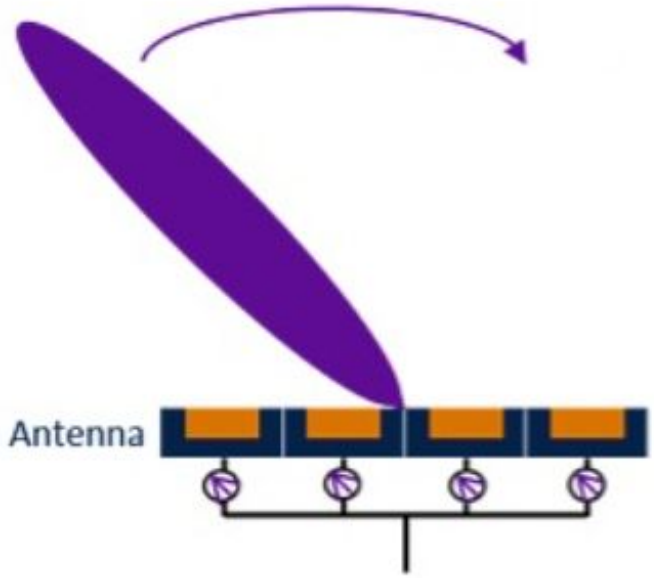
- SPEC Sheet Compatibility
  - i.e. one components outputs can be another's input
- Hardware Availability
  - Buy chip component and design PCBs and solder on chips

    OR
  - Invest in expensive hardware
    - Higher the Gbs the higher the cost
- System Controller
  - FPGA or MCU
- Type of antenna

Project Plan

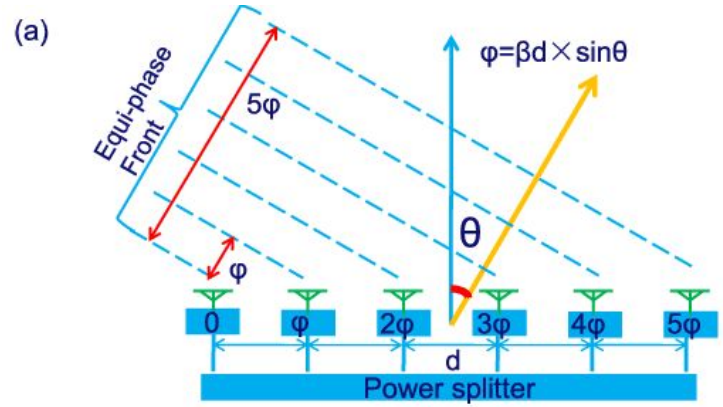
Given the broad application of our project, we must take it step by step:

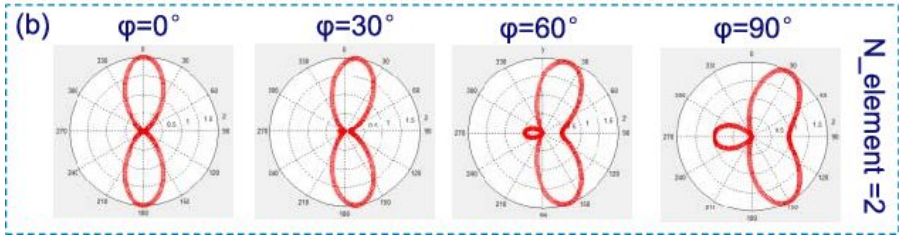
1. Buy all required hardware
2. Set up system
   - I/O signals are propagated correctly
3. Program FPGA/MCU
   - Phase shift rotations
4. Assemble final design
5. Test transmitted communication link is present

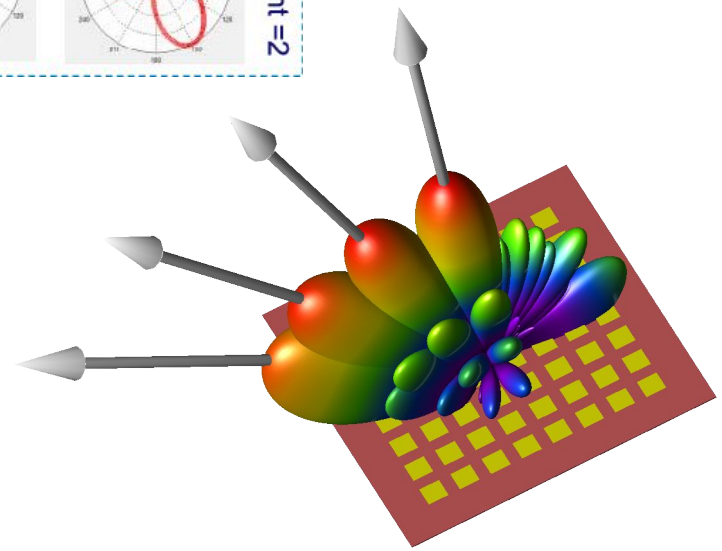


Functions

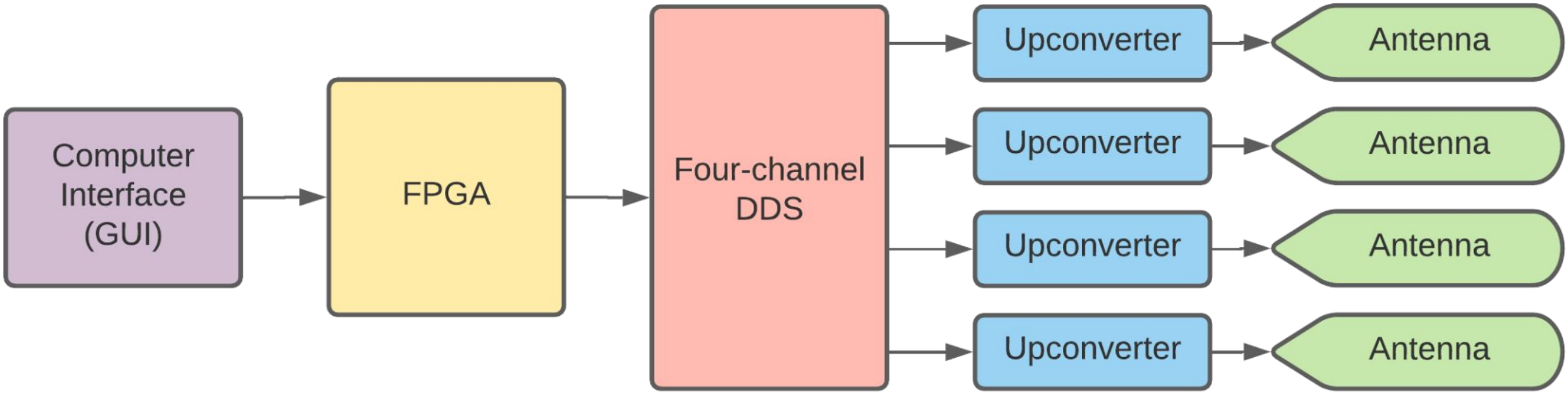
- Relate the phase difference to the desired angle of the beam
- Generate four digital sine waves
- Convert digital signals to analog signals
- Amplify the signals to the proper frequency
- Generate the radiation pattern







Functional Decomposition



Presentation Recap

- Project Background
- Project Scope
- Customer Needs
- Requirements
- Materials
- Project Approach/Plan
- Functional Decomposition

References

- C. Fulton, M. Yeary, D. Thompson, J. Lake, A. Mitchell, "Digital Phased Arrays: Challenges and Opportunities," Proceedings of the IEEE, vol. 104, pp. 487-503, March 2016.
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Questions?