Scholarship in Practice

Digital Beamsteering Phased Array

Team 311: Katheryn Potemken, Tiernen Pan, Christian Balos, William Snyder, and Andrew Cayson

Each student in Senior Design Team 311 has played an important role in the design process. The team has made modifications to the project through each step of creating it, for this has been a grim learning experience. But learning concepts in classes has made it easier for the team to make decisions throughout the project design. Each team member has important input on aspects of the design.

Katheryn Potemken:

Our project, Digital Beamsteering Phased Array, requires us to create a phased array. I am currently enrolled in EEL 4461 - Antenna Systems taught by Dr. Arigong. In this class we learn how to interpret and analyze all different properties of antennas. In fact, the last half of the class requires us to build an antenna. This class was extremely useful when it comes to interpreting the phased array used in our project. It is very important that the impedance is matched throughout each component of the design. The impedance needs to be matched at 50 ohms at each component. I learned in this class that impedance matching is necessary because it provides a channel for the power to be consistently transmitted throughout the design. Thus, properly transmitting the signal throughout the design. Impedance matching is necessary for high frequencies such as the one we are using within our design. If we were to change an aspect of our design, I would have liked to build our own antenna phased array. After being enrolled in antenna systems, building an antenna is much more manageable than I initially had thought. We would be able to control every property measurement of the antenna design and tailor it to the exact specifications that our project needs. The choice we made with buying an antenna is still okay, it just creates a lot of room for inconsistency throughout the project. Seeing how our project is playing out, I would have rather chosen to build our antenna rather than buy one.

Christian Balos:

For this project, I learned important concepts from EEL 3135. Delaying signals is an integral part of our project as without it, we would not be able to steer our signals and thus the project would be unfeasible. I feel that this engineering knowledge was attempted to be used through the VHDL project, where the code would include delays that would simulate the delay in signals. In the end, we ended up using the DDS, which has phase shifting applications and digital to analog conversion through its computer program. Next time, what I would do is use an Arduino to perform communication to the DDS as it would be interesting to learn about SPI and using the pins to communicate information in a different way.

Tiernen Pan:

The VHDL program used to implement the Taylor series for the sine function was influenced by my introduction to VHDL class. In the class we learned the basics of

VHDL and how to take the inputs that the user or component takes and how to think about making them the outputs that we are trying to achieve using Quartus. We also learned how to break the process into easy-to-understand components. The class helped me think about the outputs I was receiving from the ModelSim simulations and how to debug the VHDL code that I wrote. Although the outputs are good, the process to get to the outputs is strenuous on the FPGA and can be programmed in a way that is more “FPGA friendly”. Although the FPGA is not being used in the final design, the thought process of how to debug and think about how to get the outputs required has helped me think about how to code the python program used in the final project. My introduction to C++ class helped me think about how to code in python because it is similar since they are both object-oriented languages. To improve the project I would have started working on testing the SPI earlier and asked professors for help on how to connect with our specific DDS. Because we are not able to see where we went wrong with the SPI, we cannot figure out why the SPI is not working.

William Snyder:

Much of the knowledge needed to design the PCB for the phased array came from the circuits and electronic classes that I have taken. The design includes impedance matching networks which were used to match each of the components to 50 ohms. We also needed to calculate the width of the RF transmission lines to ensure that they matched 50 ohms as well. Much of this was taught in my Electromagnetics I and II classes where we discussed how mismatched impedances can cause a loss in signal strength and integrity. My knowledge from these classes was also used when laying out the components to properly connect the components in series or parallel where needed. Because of this knowledge, the PCB was successfully created without any shorts. However, it is likely that issues will come up during testing regarding the overall performance of the circuit. These issues could have been mitigated by designing our circuit on a different software than KiCAD such as Keysight ADS or Ansys HFSS. With the latter programs, simulations can be run to test the circuit before it is fabricated. We also should have chosen inductors and capacitors with a larger package size. When soldering by hand we found the 0201 size components to be very difficult to solder accurately. We also found out when soldering that the small size of our through hole pads made it difficult to connect our antennas to the PCB. While it did not ruin the project, in future designs I would be sure to increase the size of the pads to make the soldering process easier.

Andrew Cayson:

One aspect of the project was deciding on which parts to use on the circuit that converts our 200MHz signal from the DDS into the 2.4GHz signal required for the antennas. Specifically, the amplifiers, mixers, voltage-controlled oscillators and voltage regulators. The course that I drew heavily from to complete this task was Electronics. In my electronics course, there was an emphasis on evaluating spec sheets for electronic components. This experience added to the proficiency in which I could analyze the spec sheets for each of the components, deciding on whether or not the component would work with the rest of the circuit. I knew that this job would be challenging, but I did not realize the extent of this challenge. Some spec sheets were very straightforward and easy to read, but others were vague or did not supply the information that I was expecting to see. When I would eventually find a part that I thought was suitable for the project, the next part I found would not be suitable to work with the previous part. This resulted in a lot of reiteration in the choosing of the parts. I would find part “A” but then part “B” would not work with part “A” so I would have to go back and find a new part “A”. Then part “C” wouldn't work with part “B”, so now both “A” and “B” need to be changed and so on. Eventually, all parts were found that, to the team’s knowledge, would work together in a single circuit. The one thing I would do differently is get a better idea of the scale of the components. Each component has an image on the vendor’s website that is not to scale. I remember getting our amplifier and thinking that we must have gotten the wrong part, because it was about as small as a coarse grain of sand. I should have double checked the size of the part before ordering and used a ruler or scale to get an idea of just how large or small the part actually was. This would have also saved a lot of hassle when soldering the components, as a larger component is much easier to solder.