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Analog Devices, Inc.

This summer I had an internship at Analog Devices, Inc. Analog Devices, or ADI, is an international multi-billion dollar semiconductor company. Their headquarters is in Norwood, Massachusetts, but they have many other locations worldwide, including Japan, Ireland, and Germany. I worked at the Wilmington, Massachusetts location. They make many different kinds of electronics. Their range of products include analog-to-digital converters, digital-to-analog converts, micro-electromechanical systems and sensors, amplifiers, radio frequency integrated circuits, as well as processors and digital signal processing chips. There are many different applications in different industries for all of these parts. In healthcare, ADI parts get used as sensors for monitoring patients, as well as digital imaging. In the automotive sector, ADI parts are mainly used for safety measures like rollover sensing, antilock brakes, and corrective steering. In the industrial market, ADI parts get used for equipment monitoring to maximize efficiency. The last major market for ADI parts is consumer electronics. ADI parts can be found in almost any kind of consumer electronic devices, including image processing and stabilizations for cameras and camera phones, video processing for televisions and other screens, audio amplifiers and DSP for mobile phones, mp3 players, laptops. Overall, Analog Devices is involved in a wide variety of industries.

The group I worked in was the Digital Audio Unit. They make audio-specific DSP chips and codecs, as well as audio amplifiers. I was on the Applications Engineering team. Before getting this internship, I did not know what an Applications Engineer was.

Essentially, an applications engineer is responsible for showcasing the parts to potential customers and providing support to customers using the part. It can be described as a traditional "customer support" job merged with a sales representative, although there are additional responsibilities. Some of those additional responsibilities include answering questions on ADI's forum EngineerZone, travelling to other companies to try to get ADI parts in their products, designing evaluation boards to showcase what each part can do, and coming up with solutions for products customers want to do. From observing other DAU Applications Engineers, I decided that this was a job I would like to do. It was exciting to visit with the different companies and working on solving audio engineering related problems.

From what I learned about the job, it would be something I would like to do in the future. However, there are a few things I know I would need to improve upon. A big part of the Application Engineer's job is selling the product and providing good solutions to their needs. I would need to improve on public speaking skills. It would help to know the part inside and out. I also need to work on describing technical things to non-technically oriented people. Sometimes you may have to describe a complex circuit diagram or section of code to someone who only has a vague idea of what you are talking about. If I could work on these things, I would find myself in a good position to apply for jobs in the future.

The way I obtained the internship was by being very persistent in my efforts. I originally applied in December of 2012 on the ADI website. I followed up in March 2013. I eventually heard back in May of 2013, but unfortunately they did not think I was a good fit for the internship. I actually got another reply in late May from ADI again, but for a different internship where they thought I would be a better fit. Once I heard back the second time, it was a very quick process. I did two phone interviews over two days and heard back the next week saying I got the internship. It helped that for two previous years, other Miami students interned in the same group. My hiring manager was already familiar with the program and what we study at Miami. There are also three other employees in the Digital Audio Unit department from Miami. Two are in DAU Software engineering and one in Applications Engineering. This shows that although it is important to know all of your academic material well, it is also important to network and utilize the great reputation and alumni network associated with the University of Miami.

This internship was the perfect combination of skills I have learned in school. It required not only electronic circuit knowledge and hardware, but also knowledge of coding and DSP fundamentals, all in relation to audio. I had to learn about SigmaStudio, which is a graphical user interface developed by the DAU team used to program the ADAU codecs. I also had to learn how to use an Audio Precision and it’s software in order to effectively test the evaluation boards. I learned a new language, as well as different types of digital audio communication protocols.

A big aspect of the internship was time management. At the start of the summer, I was given three main tasks, and it was up to me to allocate time to work on each project. My heavy course load in the Music Engineering curriculum, as well as all of the extra-curricular activities I do, helped me prepare well for this aspect of my internship. I had to be very self-motivated since there was nobody watching over my shoulder. Overall, I felt that I did a good job budgeting my time and planning for other small tasks that would come up throughout the summer.

Another cool part of the Application Engineering Internship was that I got to meet with outside customers and hear about cool new ways they would be using ADI chips in their products. I cannot talk about specific companies, but there were many innovative products I was able to learn about and how they implemented the different ADI parts.

One thing I really liked about working at Analog Devices was the sense of camaraderie between coworkers. They have a big emphasis on the New College Grad, or NCG. I got to know the NCG group of my coworker who was hired there last year. I spent a lot of time with the other interns, having lunch, and doing things after work. They even had several intern days where we did fun activities like bowling. At the end of the summer, there were a few days were all of the interns presented. It was interesting to see all of the other work people were doing.

I learned a lot working for such a big company. This was my first time working for a large-scale company. The Digital Audio Unit Applications Engineering team was really small and I liked working with a close-knit group of people on the same team. I really liked working on a small team. In the DAU team there were six or seven employees at my location, with other DAU Apps members at other locations around the world.

The first project I worked on was filter design and implementation in MATLAB. I cannot go into detail about the specific kind of filtering or papers due to non-disclosure agreements, but I will talk about the task in general. I was given the end goal for the filter and was given an AES published paper and had to derive the transfer function and simulate it in MATLAB. This was given to me by one of the DAU Software Engineering team members. It proved to be the most difficult of all of the tasks. I made quite a bit of progress on it and got some results, but was unable to fully complete the task. I had had some experience doing more basic block diagrams in MATLAB from Digital Audio I but nothing this complex. I ended up reading a lot more papers on similar filter types too. What I took away from this task is that it is okay to say you do not know how to do something. The guy who gave it to me wanted to see if I could do it, otherwise he would give it to a contractor to do. I did learn a lot more about MATLAB, block diagrams, filtering techniques, and ways to research very specific academic topics.

The second project I worked on was a sound card. I modified and debugged existing code. This project was also assigned by the DAU Software Engineering team. The purpose of the sound card was to give customers a cheaper alternative to using an Audio Precision. It provides high-quality multi-channel audio for accurately testing ADI audio codecs. The microcontroller will take user inputs and make hardware adjustments accordingly. The cool thing about this project was that other Miami students interning at Analog Devices started it two summers ago. The big part of the project was that it has a dual core microchip on it. The XMOS chip was cool to learn how to program. I had to lean XC, which is like C, but it adds functionality for making programming on two cores with multi-threading "easier". It supports up to sixteen threads. The challenge was understanding how the chip was organized in terms of what set of pins were on what port number, and what port number was on what core. Additionally, ADI had changed some of the pins from the default XMOS layout to better suit the project, which was confusing at first. The code is written in XDE, or XMOS Development Environment. It was similar enough to Microsoft Visual Studio for me to figure out quickly how to use. XMOS Development Environment is based on Eclipse architecture.

I learned about source control with this project. I had to become familiar with TortiseSVN. It essentially lets multiple people work on the same code without each person overwriting the other person's work. For a large scale code project like this, organized source control is an essential part of it. A really useful feature of source control is being able to compare your current code to a previous version, so you know what was changed. You can then choose to accept or decline adding the new code, or merge the two.

There were a few things I had to achieve on the XMOS board in order to get it to the stage where the DAU Software Engineering team wanted it to be. Right before I arrived, there was a dual inline package switch of 8 switches that was added to the design. I had to program all of the functionality of those switches. The switches controlled settings for the ADAU1442 part that was controlling the routing of the signals. It would load register data from SigmaStudio to the ADAU1442 chip. The SigmaStudio project was pretty complicated, with lots of routing happening. I had to really delve into the most basic levels of how the chip was working in order to properly write the correct values.

The way I verified my code was working was through the use of a Total Phase Beagle USB analyzer. I learned about different communication protocols including I2S, I2C, SPI, and TDM. When you make a change in SigmaStudio, it appears in the "Output" window. This is useful for debugging. The Beagle recorded the hex values being written to the chip and I was able to compare the values recorded to what SigmaStudio says should be written. When they did not match up, I could go into the code and see correct bitmasks.

A bug that was in the chip when I inherited the project was that the address of the commands was flipped backwards. This was fixed by doing some bit masking and shifting. In fact, a lot of what I had to do boiled down to bit masking and bit shifting. This is because of how the XMOS chip's pins and ports are laid out. In order to change the value of one pin without affecting the other pins on the port, you have to use bit masking. The way the XMOS part is programmed is through the XTAG connector. The USBi connector ADI provides programs the ADAU1442 via an eight-pin header.

Another part of getting the XMOS board ready to go was fixing a USB power issue. What was happening was that power was being sent to the daughter board before the ADAU chip was finished being programmed. This could potentially cause issues. I had the power get sent after the chip was done getting programmed by having it detect when it was done. This task was cool because I could actually see on the oscilloscope what was happening at the test points. I also had to investigate glitches in the USB power signal. It was thought that they could also cause problems when connecting to another board. It turned out that these were from the code that was written by the XMOS chip itself. This had nothing to do with what the DAU team was working on and was from the XMOS manufacturer.

This XMOS project was a great project to work on because it forced me to learn a lot of essential skills required when working on embedded programming. I learned how to analyze signals with an oscilloscope. I probed four test points, power, PLL, Clock, and Data, to see where the errors were when the data was being written. I also learned how to program a dual-core processor and have commands run simultaneously on separate cores and multiple threads to be more efficient and run faster. I learned about different communication protocols like I2S, I2C, SPI, and TDM. I showed that I was able to complete a technical task on time.

The third project I worked on was building noise-cancelling headphones using ADI parts. This was a really awesome project and was probably my favorite. The goal of the project was to improve upon an existing headphone demo someone in DAU Applications Engineering had done some time ago. My demo would be used to showcase new ADI parts and demonstrate the kind of results potential customers. The parts that were used were the ADAU1772 and the ADMP3000z MEMs microphone. The MEMs microphones were prototype microphones that had a really low cutoff frequency. The ADAU1772 is four-input two-output codec with a DSP engine. It is designed specifically for audio applications.

The first step of the project was to attach the microphones to the evaluation board I was given. I had to find the right spot on the schematic to solder on the microphone leads. This was my first real experience working with lead free solder. I learned that you have to use a lot of flux to get the solder to flow.

Once I verified I could get the microphones working on the evaluation board, I started to build the physical demo unit. I was given an old Audio Technica pair of noise cancelling headphones. I removed essentially all of the insides except for the drivers and wiring from ear to ear. I then experimented with different positions of the microphone mounted inside the ear cup. Things I took into consideration when positioning the microphone on the headphones was isolation from the driver, feedback, and general aesthetic looks. I had to attach the correct leads from the microphones to the specific parts of the tip-ring-sleeve eighth-inch connector (hot, cold, and ground).

Another big step of the project was testing the built demo. There is a sound room that is an isolated room with panels and soft materials that is used for testing equipment, as well as conferences and video shoots. I set up my test in this room. There was a head and torso dummy. I had to order replacement parts for the head and torso dummy from the company that made it. This was a unique experience because I learned about how ordering in a big company works. I had to get approval from certain people before ordering replacement parts. I also had to get in contact with the sales representative from G.R.A.S., the company who makes KEMAR, the test dummy. Once some higher-up people in DAU approved my order, the new parts came in and I was able to start my testing. The parts I ordered were two new sets of pinna, or outer ear simulators molded from silicon.

I also had to create documentation for every step of the process. This was so that when someone on DAU came back to work on the project at a later date, they would be able to pick up where I left off. This documentation would also serve as a template for future user guides that would be available to customers wanting to get into the active noise cancelling headphone business with the ADAU1772. From working on this project, I learned a few things. One skill I learned was how to read through data sheets. I had to know the ADAU1772 data sheet and user guide front to back.

Some of the other small tasks included testing setups and verifying data from customers. I learned how to use and Audio Precision and its bundled software. I would have to take measurements and compare them to the customer's numbers, trying to replicate their setup. For example, they might say, "What is the lowest voltage the part can run in TDM4 with no PGA" and I would have to set up the part in SigmaStudio, download it to the evaluation board, and take measurements with a voltmeter. I would be sending the audio data and clock with the Audio Precision.

The last part of my internship was giving a presentation. This took place during my last week of the internship. I had to prepare a ten-minute presentation on my summer. It was given to a room of roughly forty people. It was a mixture of other interns and Analog Devices employees from other parts of the company. I was one of about ten other interns that presented that day. I learned about other aspects of the company I had little involvement with, such as the MEMs group or the Isolations group.

Overall, I would say this was a very positive internship experience. I learned an invaluable amount from all of my DAU co-workers. I got to work on three projects, which turned out to be excellent resume material. The relationships I formed with other interns and ADI employees will serve me well in the future. It showed me that working at a typical 9-5 job at an engineering company would be something I would enjoy post-college.