EE/CprE/SE 491 - sddec22-13
Simultaneous Call Transmission (SCT)
Week 7

March 21st, 2022 - March 27th, 2022
Client: Collins Aerospace
Faculty Advisor: Dr. Andrew Bolstad

Team Members

- Hani El-Zein - *Digital Signal Processing Lead and Research*
- Sullivan Jahnke - *Project Manager, Lead Communicator, and Machine Learning Lead*
- Tyler Mork - *Reports, Communicator, Co-Webmaster, and Communication Systems Co-Lead*
- Json Rangel - Reports, *Communicator, Co-Webmaster, and Communication Systems Co-Lead*
- Austin Rognes - *Research, MATLAB Lead, and Co-Webmaster*

Week 7 Summary

Week 7 consisted of further clarifying how to go about implementing DC baseband. Our meeting with Collins before spring break resulted in a turn around in the ways we'll be implementing the Simulink simulation signals. It was recommended that we pursue this problem within the DC baseband. This further led to the discussion of implementing an I-Q demodulation process as shown in Figure 1_1. This turned out to be what most modern RF receivers utilize for software based processing. Any RF signal can be taken and separated into two data streams, one within the I plane and the other within the Q plane. The difference between the I and Q data streams is that the Q channel is phase offset by 90 degrees. These two data streams contain all necessary information for signal analyzation, and are not confined to an RF signal that was IQ modulated but can demodulate any transmitted signal. The demodulation process results in two data streams that have been multiplied by the local oscillator frequency and low pass filtered to consist of DC baseband data. Further circuitry components can be used to manipulate the output data as needed such as DACs or ADCs.

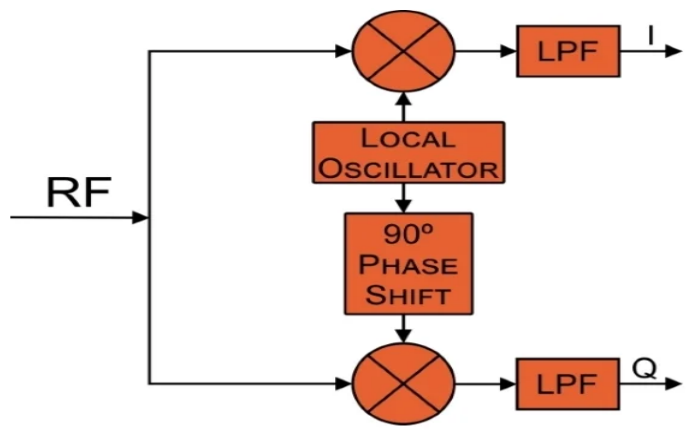

Figure 1.1: High-level diagram of an I-Q Demodulator

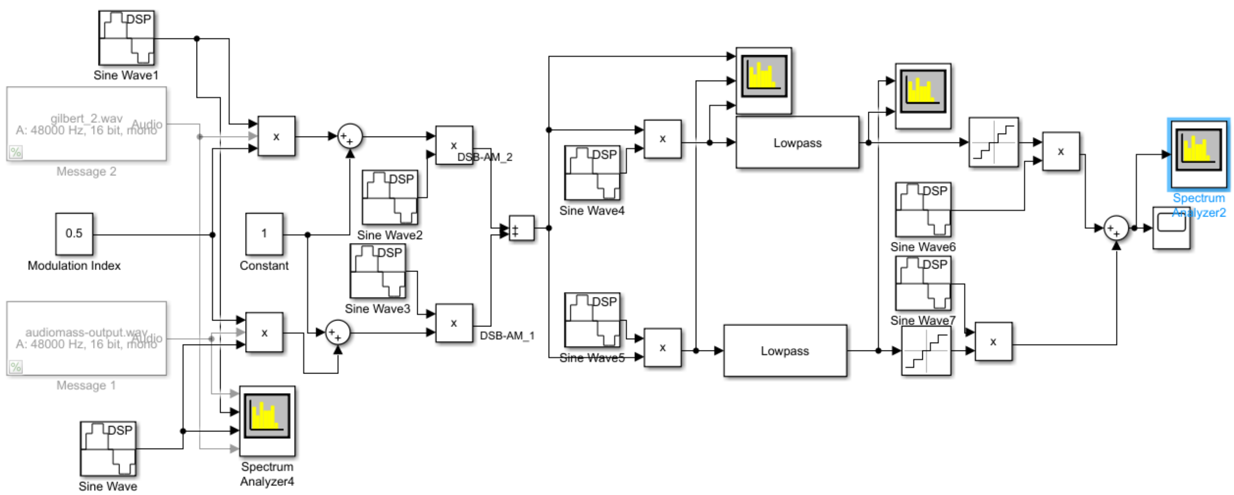

Figure 1.2: Simulink Construct of I-Q Demodulator

Major ground has been made on the deep learning aspect of this project where we will be pursuing the code in the open-sourced platform TensorFlow with the Keras library that is built-in Python. Keras provides multiple neural network tools as well as signal processing transformations such as Fast Fourier Transform. We have undergone a sample simulation of a signal with noise that is subjected to the deep learning algorithm that is able to produce a predicted signal before being distorted by noise. It was a good basis to begin working from, with a now deeper understanding of the coding platform.

https://git.ece.iastate.edu/sd/sddec22-13/-/blob/master/examples/NeuralNetwork.py
This file in our git repository is an example of using keras to build a neural network. It is a program that can take a noisy signal and predict what the signal would be without noise. It also plots some data to show what the program is doing, shown below.

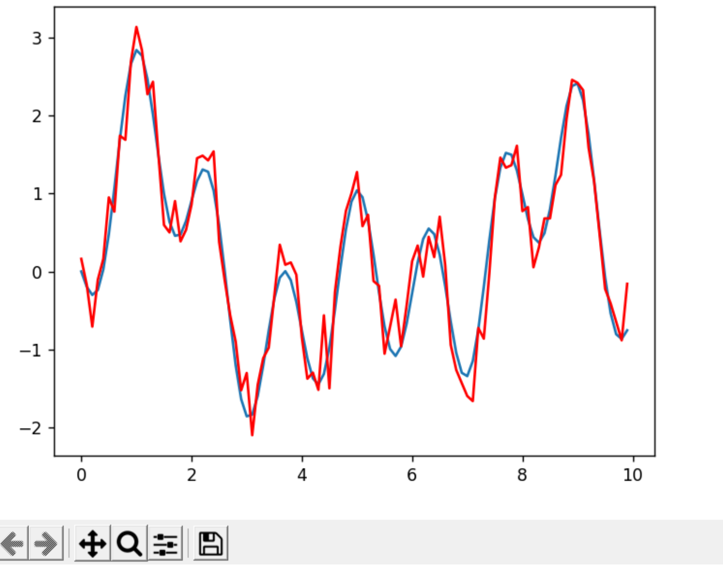

Figure 2: This shows example data created by the program. The blue line represents a signal without noise, and the red one is the same signal with noise added.

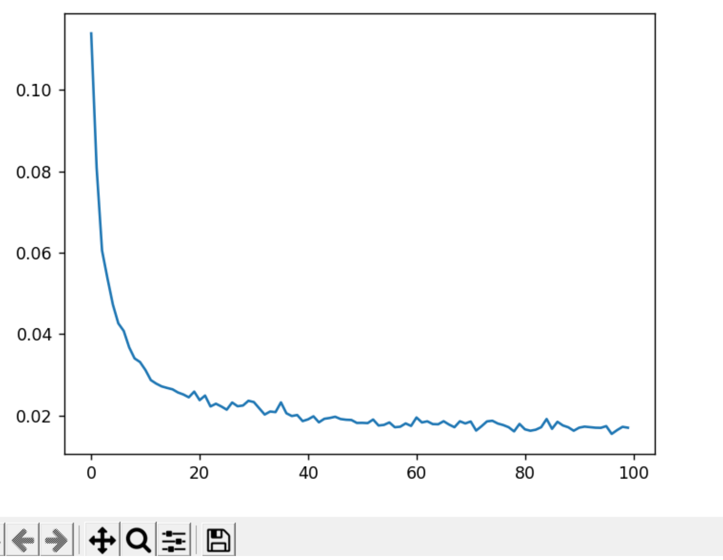

Figure 3: This shows the error of the neural network's predictions with time. As you can see, the error decreases with the more time it is training. When the line becomes flat, we know that the network is trained and ready to go.

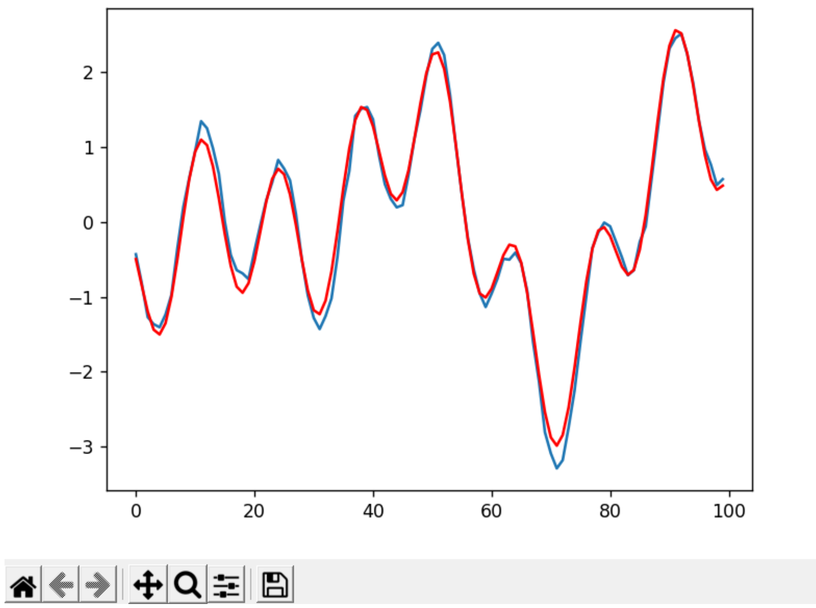

Figure 4: This shows the final results of the prediction. The red line is the actual test signal and the blue line is the signal that the network predicted.

<u>Past Week Accomplishments</u>

This past week, we met with Dr. Bolstad to learn in greater detail about what baseband modulation is and get a general idea of how we can build a baseband modulation system in Simulink. The hardware side of the team did additional research into I-Q demodulation, which will be relevant to our project. I-Q demodulation will produce both real and imaginary signal data, which will be necessary for producing the training data for our machine learning algorithm. We also got a brief start on the new simulation file.

The software side also made excellent progress in testing out a machine learning algorithm. This test gave the team a breakthrough into how we might be able to apply this test to an audio signal and gave great relief to the hardware side in creating the training data. Initially, the hardware side of the team had some concerns that they would have to modify the Simulink file to create data that the machine learning algorithm could easily read.

Individual Contributions

Team Member	Contribution	Weekly Hours	Total Hours
Hani El-Zein	Researched into DC baseband	2.5	20
Sullivan Jahnke	Created an example neural network using our chosen framework.	4.5	22.5
Tyler Mork	Researched and tested simulink implementations of signal distortions (noise, reflections, doppler effect). Researched IQ demodulation and real-world applications.	5	26.5
Json Rangel	Learned more about baseband modulation, I-Q demodulation, and digital modulation schemes. Also reserved rooms for additional team meetings.	3	25.5
Austin Rognes	I tried to implement Theano, and then moved to TensorFlow.	2	20

Plans for Upcoming Week

Upcoming plans for our project involve beginning a new simulink signal simulation for IQ demodulation. The process will include taking an RF signal input and subjecting it to IQ demodulation where the I and Q channel will be derived through multiplication of a local oscillator(carrier frequency) with the Q channel phase offset by 90 degrees. Each channel will require low pass filtered to remove any unneeded, high frequency components. It will require further research into what can be done with the data information contained in each channel. We believe, once the signal output is at baseband, it can be implemented into an ADC to gather digitized data points of which can be subject to any sort of algorithm analysis we provide. Within, we will be able to design our low pass filters and the ADC in order to achieve proper demodulation.

Further testing of the deep neural networks within Keras will be performed where, using example codes, we attempt to test algorithms that utilize signal transformations and analysis that we may foresee ourselves using. Some of those techniques being the Fast Fourier Transform to analyze frequency components of signals or finding maximum and minimums values. Due to the nature of the IQ demodulation process, we may need to look further into how the phase differences are affected during decimation and filtering and if any information can be derived from the phase relationships within each channel.