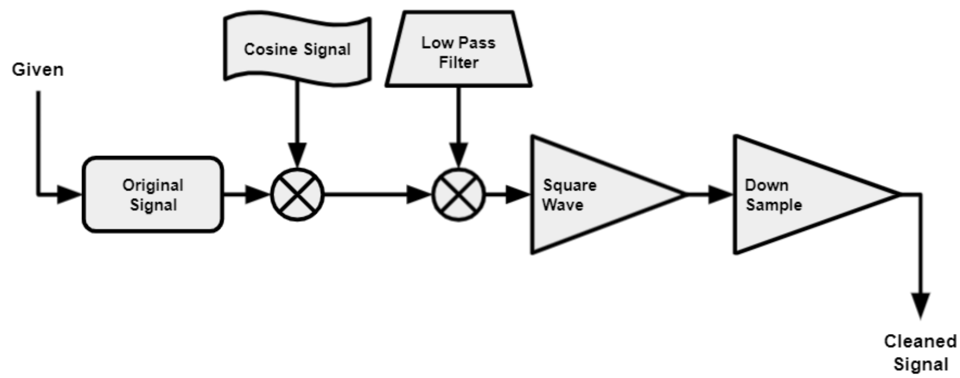
Tolulope Oshinowo Engineering Systems Analysis: Signals

ESA Signals Acoustic Modem Project Report

Link To Demo Video: https://www.youtube.com/watch?v=oyXleEOTbJg

During this past half-semester in ESA Signals, we spent a considerable amount of time learning about how signals can be utilized and manipulated to convey different types of information. During the first few weeks of class, we were reintroduced to the continuous time and discrete time signals that we had scratched the surface on in QEA, but now we would be learning about the mathematical and applicational reasoning for why signal transforms worked. From there we spent time learning about the different domains that signals existed in and the use cases for each respective domain. Once we had grasped the fundamentals of signals analysis we then began to interact with these signals through operations like multiplication, convolution, and integration. In various case studies ranging from piglets to Kanye West, we gradually built our confidence in operating on different signals. All this work through each in-class problem set and homework assignment would prepare us for our final project: implementing an acoustic modem.

Thanks to the previous homework assignments and the pre-defined scaffolding for this project I had an initial sense of direction but seeking the knowledge of the teaching team also proved to be incredibly helpful. Combining all these resources allowed me to come up with this basic block diagram schematic of the modem:



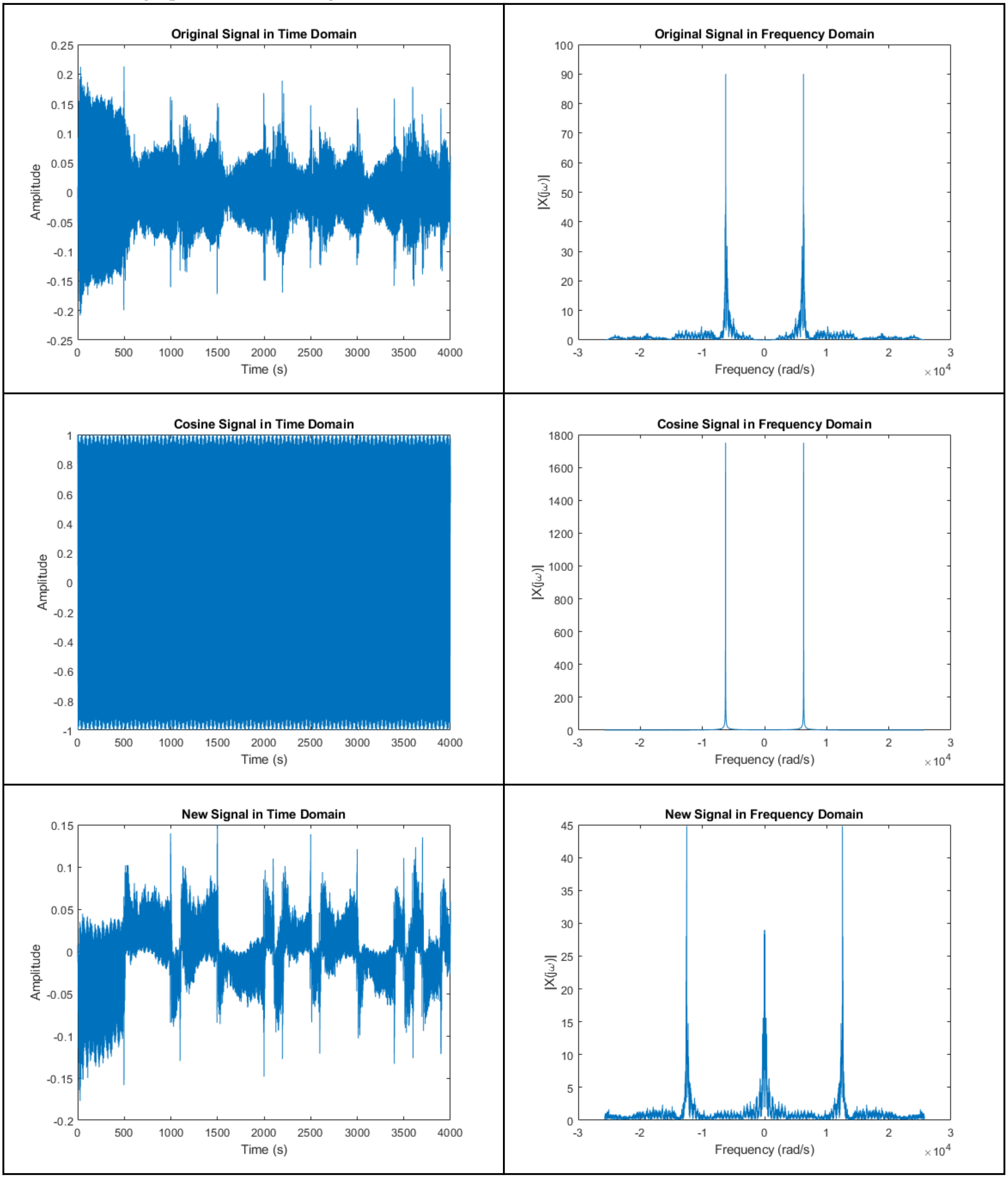
In this block diagram several operations are performed on the corrupted signal to refractor it back into a legible state. First the given original signal is multiplied by a high-frequency cosine signal in the time domain. Then the high-frequency noise (from the multiplication with the cosine signal) in this new signal is filtered by a low pass filter through convolution. The filter is constructed using a basic sinc function. Once the aforementioned new signal has been filtered, a square wave function is generated from the signal's elements in the time domain. Next the sampling rate on this newly filtered square wave signal is decreased to 100Hz, effectively matching the sampling rate of the original transmission (as seen in modem_tx.m), and the signal is trimmed. Finally this newest iteration of the signal has its amplitudes mapped to binary values and then the BitsToString() function is called with the signal being passed in as an argument. From all this we retrieve the message "Hello".

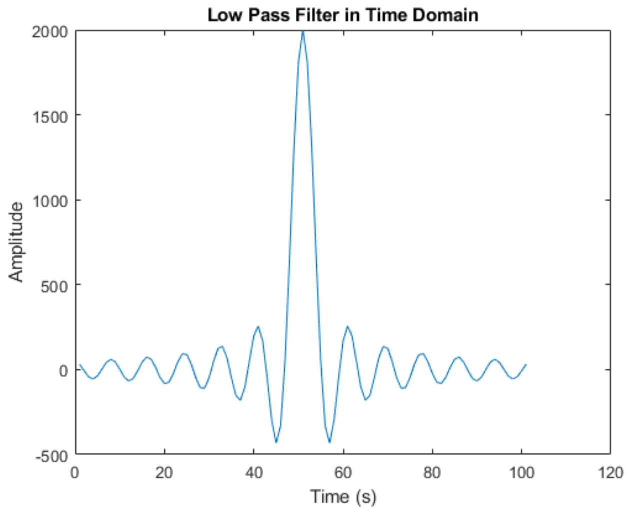
Below are all the MATLAB equations that went into the implementation of this acoustic modem:

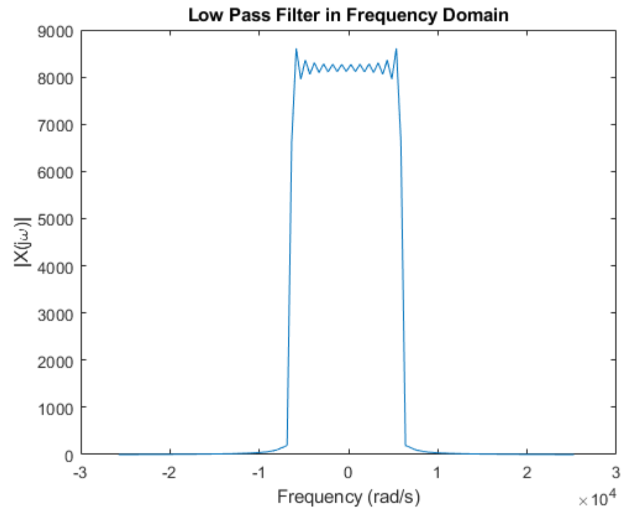
Given Equations	Setting Constants	General Equations	MATLAB Equations

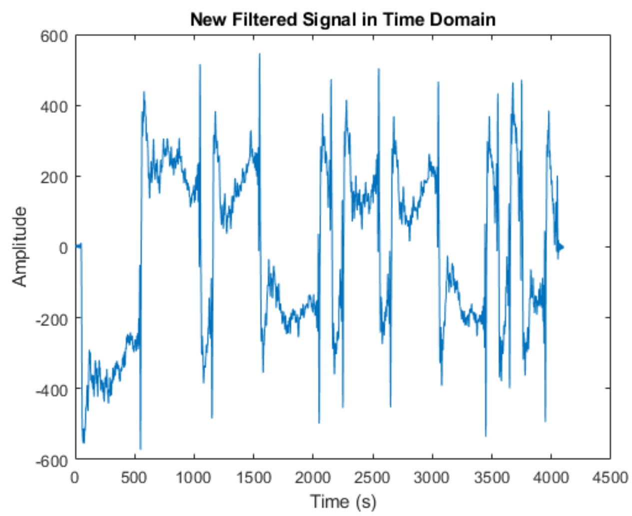
start_idx = find_start_of_signal(y_r,x_sync);
y_t = y_r(start_idx+length(x_sync):end);
	Primary Constants:
	Fs = 8192;
	f_c = 1000;
	Secondary Constants:
	t = [-50:50]*1/Fs;
	W = 2*pi*f_c;
		y_t = y_t(1:msg_length*8*100);
		cos = cos(2*pi*f_c/Fs*[0:length(y_t)-1]');
		sig = y_t.*cos;
		h = W/pi*sinc(W/pi*t);
		sig_fl = conv(sig, h);
			sig_sq = square(sig_fl/500);
			sig_dn = downsample(sig_sq, 100);
			sig_tr = sig_dn(2:length(sig_dn));

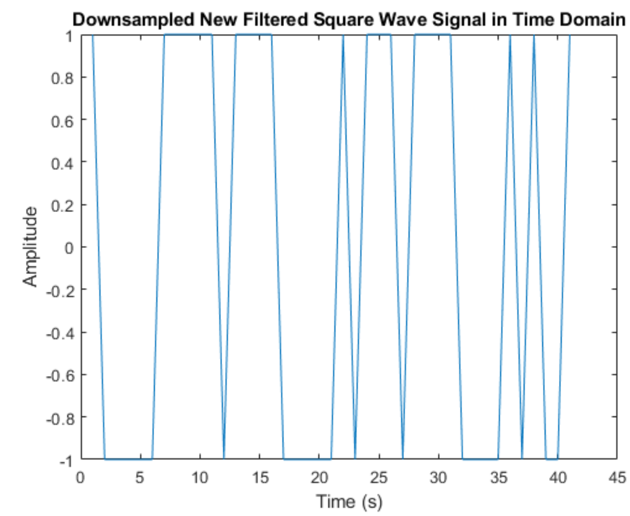
Each step throughout this process was an integral building block to get to the goal, and with each major equation came graphs that showed gradual progress taking place in the signal refactoring process. Below are all of the resultant graphs from each stage from the code:

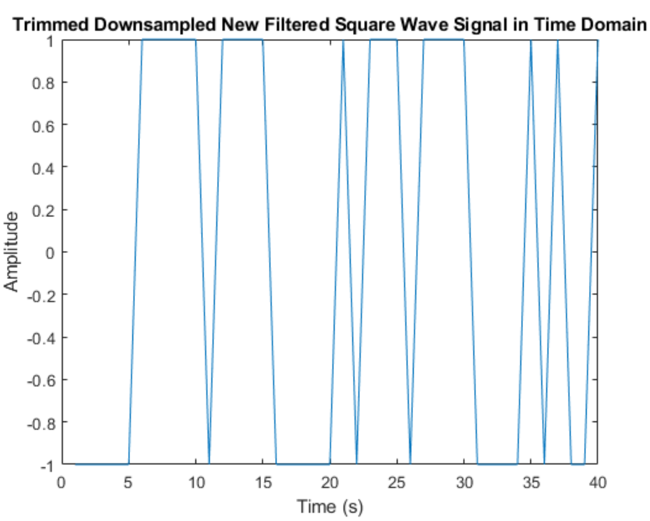


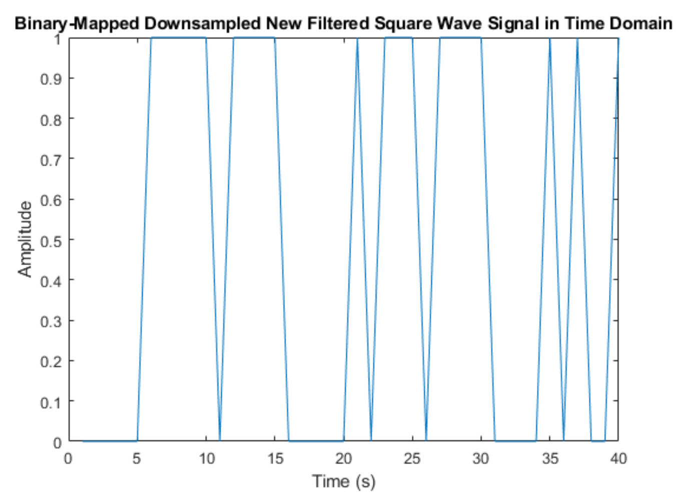












In conclusion this project served not only as an engaging exercise, but also as an opportunity to apply everything that was learned about throughout ESA in a realistic setting. Looking forward, I am sure that there will be scenarios where the topics and strategies that we learned about during this semester will show up again, and thanks to ESA Signals I will be prepared.