6.111 Final Project Abstract - J. Abel, J. McGuire
QAM Receiver for Video Signals from a Quadcopter Camera

For our 6.111 final project, we would like to make a system to receive and demodulate an NTSC video signal from a quadcopter with a first-person view camera. This signal is AM modulated with vestigial sideband techniques onto a 5.8 Ghz carrier. We propose a switched antenna matrix for reception that can use multiple high-gain directional helical antennas aimed in different directions to increase the integrity of the received signal. The receiver will have two tuners, one with a high speed ADC after the intermediate frequency conversion stage to receive the actual video signal, and one with a rectifier that feeds into a low speed ADC, serving as a power detector. In this way, we can receive video with one antenna while simultaneously scanning the power detector tuner across the remaining antennas to determine when it is necessary to switch to a new antenna as the quadcopter moves. This project is essentially the receiver component of an SDR, as we intend to digitize the analog signal immediately after the intermediate frequency converter stage. The system will also require an automatic gain controller that will be controlled by the FPGA to deal with varying power levels as the quadcopter moves. We will use an external high speed PLL controlled by the FPGA to generate the 5.8 GHz local oscillator signal for the receiver.

The core of this project will be to implement the signal processing modules to decode the video signal on an FPGA. We plan to use a baseband converter to recover the originally transmitted signal from the FPGA input. This will work by extracting the frequency and phase of the intermediate frequency and sampling the input signal exactly at the peaks and valleys of the IF sine wave, yielding the original baseband video signal. This signal will then be filtered, and the pixel luminance information and video synchronization signals will be extracted and used to generate pixel values for a black-and-white digital video stream. This will be sent via SPI to a Raspberry Pi for display on a monitor. Time-permitting, we hope to also extract pixel color information from the chrominance signal, which will allow us to generate real-time color video. In addition to decoding the video signals, the FPGA will also be used to control the antenna selection by measuring the power of signals from each antenna and determining from where the strongest signal is received. Using this information, the FPGA will be able to drive a switch matrix to control which antenna will be used to receive the video signal, which is important given that the camera is mounted on a mobile drone. Ideally, this digital system will be coupled with an analog system, which will perform the necessary filtering and amplification of the received radio signal to allow it to be digitally processed. Given that the analog system needed would be of comparable scope and complexity to the digital system, we plan to test the digital system in isolation using a simulated input signal. This will be generated from a pre-recorded video signal which is processed in MATLAB to have the same data structure as the output of the analog portion of this system.