Bryan Jangeesingh and Jonas Rajagopal
11/04/24
6.S965 Final Project Proposal

Data will be received via two (initially one but the behavior is identical) Hamamatsu C5658 Si APD detectors which transmit an analog signal. In the final use case, these will be detecting transient grating spectroscopy (TGS) signals, but they can be used to detect any light source. The incoming signal has a detection limit of 1 GHz wideband, so the ADC will need to sample at least 2x faster than this. The RFSoC's ADC and associated FIR filters will convert the detector voltage to a digital, 1 GHz input signal.

A third input to the system is a trigger. Initially, and in all Electronics Lab uses, this will simply be an artificial 1 kHz trigger. Eventually, a laser (STG-03E-140) from Teem Photonics will replace this artificial trigger.

The system behaves as such: when the trigger input is high, the inputs from each detector are sampled for a small time period. For example, let's say the system collects 1,000 data points in a single sample; this means that each sample takes 1/1,000,000th of a second to retrieve all of the 1,000 data points. The 1 kHz trigger dictates there will be many cycles between consecutive triggers, so there is ample time for any computation. 100 (arbitrarily chosen for now but will be an adjustable parameter) successive samples will be averaged, so there will need to be running buffers for each of the 1,000 data point indices "i-th position after the trigger" and after 100 samples, the values will be averaged.

These averages will then be transferred to a Jupyter Kernel via PYNQ and a live display will show the detected values. The detected values should be updated at a rate of 10 fps (1000 samples per second and 100 samples per display period). This data can then be analyzed and plotted directly on the PYNQ interface. Additionally, in a separate mode, far more samples will be averaged (say 10,000) but the process need not repeat itself.

The basic functionality relies on connecting an external detector to a new RFSoC and working through the process of data collection to ensure no samples are lost nor is it sampling at half the expected rate. All other functionality relies on this tenet and should not be limited by any resources on board.

A successful implementation of the system presented would greatly improve the data collection process for transient grating spectroscopy aiding the process of lowering the barrier to entry for the powerful technology.