Developing a High Speed Data Acquisition System For Nuclear Physics Experiments Using FPGAs

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(Dated: June 10, 2022)

I. PROSPECTUS

The study of fundamental symmetries has become a prime focus for nuclear and particle physicists, as it provides a deeper understanding of the nature of the universe and its formation. For example, the matter-antimatter asymmetry of the early universe, also known as baryon asymmetry, remains an open question in cosmology, and the study of fundamental symmetries could provide the answer. In particular, the Neutron Optics Parity and Time Reversal Experiment (NOPTREX) collaboration is studying the violation of time-reversal symmetry. This symmetry violation is required by our current model of the Big Bang in order to explain why the universe formed as matter and not antimatter.

To investigate this asymmetry, the NOPTREX collaboration is using a low energy neutron beam to measure n-gamma resonances in heavy nuclei, which will be measured by an array of 24 sodium-iodide (NaI) scintillation gamma detectors. Therefore, this measurement will also require a high speed data aquisition system to process the large amounts of data from the array in real time. By using field programmable gate arrays (FPGAs) to digitize and filter the analog signals from the detectors, it is possible to implement high performance trapezoidal filters that can efficiently determine the energy and timing of each detector pulse with a high level of precision.

In this research, I will use the CAEN SciCompiler software to develop a firmware for the DT5560SE open FPGA 32 channel digitizer that uses a trapezoidal filter and multichannel analyzer (MCA) to record the energy of each detector pulse, as well as charge integration to measure the detector current over a given time period. The block-coding style of the SciCompiler application simplifies the firmware design process, and will allow for a gradual introduction to computer logic. Subsequently, I will use the Vivado coding environment to develop firmware for the KRM-4ZU27DR development board. This board uses many high performance components to process high frequency digital signals, and will be used to development new methods of data acquisition for nuclear experiments. Upon the completion of this research, the DT5560SE digitizer will be

used to acquire data for the NaI array being built at Eastern Kentucky University, and I will have gained a deeper understanding of computer logic and firmware development for FPGAs.