Sensor control and DAQ software development for use with underground cryogenic experiments operating transition edge sensor light detectors

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Abstract

The Cryogenic Underground Observatory of Rare Events (CUORE) experiment searches for the neutrinoless double beta decay ($0\nu\beta\beta$) in 130Te at the Gran Sasso National Laboratory (LNGS) in Italy. In order to catch the rare decay event, highly pure crystals of tellurium dioxide (TeO2) are used as bolometers under ultra-cold cryogenic temperatures. To maintain the sensitivity of the crystal detectors, temperature must be in the millikelvin range and is carefully monitored and maintained by a cryostat. In order to monitor the cryostat, the Triton software communicates with the pressure sensors to provide continuous feedback. Switching from Leybold CENTER THREE to GRAPHIX THREE pressure controller, the communication between Triton software and GRAPHIX THREE becomes different from that with CENTER THREE. I developed a translator program to facilitate serial communication between the devices. This translator program is written on a Raspberry Pi in Python which can be generalized and extended to other monitoring applications. Also, in order to monitor the data detection with the transition edge sensor light detectors (TES) outside the Faraday room, we have developed a software that allows instant display with the data taken. This aims to be a high-performance DAQ that may be of use to a variety of experiments. Here I will explain the design of the translator program, and I will also discuss the implementation of the data acquisition software in LabVIEW which allows remote monitoring of data taking and can generate real-time noise power spectra with configurable averaging, allowing for quick evaluation of noise conditions.

Individual contribution

I contributed to the CUORE experiment and CUPID RD by coding up the translator program, in both LabVIEW and Python, and a LabVIEW DAQ software.

For the translator program, to minimize the size of the external translator for serial communication interception between CENTER THREE and the computer running Triton software, I have suggested making Raspberry Pi the carrier of the program. I chose to write the translator as a state machine that switches between states to allow communication for different serial commands of devices. I also incorporated logging functions into the Python code which makes tracing pressure values much easier. I implemented rotation to the logging system that rotates log files every 24 hours.

The LabVIEW DAQ also operates as a state machine that switches between modes for data acquisition with both real-time displays of time and frequency domain and saving to hdf5 files. This LabVIEW DAQ supports multichannel digitizer input signals with manual configurations for channel samples and sampling rate. The feature of saving data acquired as HDF5 files is also developed. To store the data in HDF5 files more efficiently, I write each channel into independent groups in the HDF5 files, and write metadata and actual data acquired from each separate channel as attributes and datasets in their respective groups. I also decided to record extra datasets to store timestamp information of each waveform from each channel. I am currently making use of this feature to perform data continuity checks. I also am writing codes to analyze the DAQ output files to implement an optimal chunk size and compression ratio. I also regularly update the group on all my work every week.