NE 204: Advanced Concepts in Radiation Detection and Measurement

Experiment 3: Digital Signal Processing with LaBr

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Purpose

In this experiment, a LaBr scintillation detector with fast response and high light yield will be used to study basic digital signal processing techniques for spectroscopic and high count rate applications. In addition, digital filters for extracting timing information with high precision can be explored.

Approach

A LaBr scintillation detector will be used to evaluate triangular and flat-top shaping filters to determine pulse heights for gamma-ray spectroscopy. A combination of shaping filters, with fixed or variable shaping times, will be developed and evaluated for high count rate spectroscopy.

Pulse Shaping for Gamma-Ray Spectroscopy with Triangular Filters

Investigate the application of the triangular/trapezoidal shaping filter developed in experiment #1 to the signals from the LaBr detector. Repeat the procedures of Lab #1 (for gamma-ray spectroscopy in the absence of rate considerations) with the LaBr detector to determine the optimum filter parameters and the Fano factor for the system. Investigate the non-proportionality of the scinitillator and quantify the impact on energy resolution.

Required

- Experimentally determine the peaking and gap times of the digital trapezoidal filter that optimize energy resolution of the LaBr detector (ignoring pulse pileup considerations).
- Using the optimum filter parameters, measure the energy resolution as a function of incident gamma-ray energy from 60 keV to 1332.5 keV. Estimate the Fano factor and evaluate the effects of scintillator non-proportionality on energy resolution.

Adaptive Filtering for High-Rate Gamma-Ray Spectroscopy

Digital signal processing techniques will be used to investigate the tradeoff between energy resolution and pulse pile-up/throughput with the fast LaBr detector.

Required

- Repeat the procedure for studying pulse pileup from experiment #2 with the LaBr detector.
- Compare the throughput and pileup effects on energy resolution to those seen in a coaxial HPGe detector.

Optional

- Implement a fast shaper (for pile-up detection) and a series of slower shapers (for spectroscopy). Investigate adaptive filtering techniques in which the event time distribution information from the fast shaper dictates which of slow shapers is used to determine the pulse height on a per-event basis. Can you develop an adaptive scheme that improves spectral performance at high count rate relative to the non-adaptive filtering schemes from the previous section?

Time Resolution

Investigate the timing performance of the LaBr scinitillator with a coincidence setup with LYSO or a plastic scintillator. This task is optional.

Optional

- Set up a coincidence measurement between the LaBr and either the plastic or LYSO scintillator.
- Use the coincidence setup to experimentally determine the time resolution of the LaBr detector. Be sure to discuss the limitations associated with determining timing resolution in this manner.
- Investigate the effect of various digitally-implemented time pick-off schema (leading edge, CFD, etc.) on the measured time resolution of the LaBr system.