Realizing Real-Time Capabilities of an Embedded Control System for Fast-Neutron Scintillation Detectors

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Abstract

Scintillation detectors offer a single-step detection method for fast neutrons and necessitate real-time acquisition, whereas this is redundant in two-stage thermal detection systems using helium-3 and lithium-6. The relative affordability of scintillation detectors, and the flexibility of fast digital acquisition systems, has enabled entirely new measurement setups that can consist of sizeable detector arrays. These detectors in most cases rely on photo-multiplier tubes which have significant tolerances and result in variations in detector response functions. The detector tolerances and other environmental instabilities must be accounted for in measurements that depend on matched detector performance.

Recent advances made to a high speed FPGA-based digitizer technology developed by Hybrid Instruments Ltd (UK) and Lancaster University (UK), with support from the European Joint Research Centre (Ispra) and the International Atomic Energy Agency (Vienna) are presented. The technology described offers a complete solution for fast-neutron scintillation detectors by integrating multichannel high-speed data acquisition technology with dedicated detector high-voltage supplies. This unique configuration has significant advantages for large detector arrays that require uniform detector responses. We report on bespoke control software and firmware techniques that exploit real-time functionality to reduce setup and acquisition time, increase repeatability and reduce statistical uncertainties.

Keywords

Fast neutron, Recent advances, FPGA, Digital technology, Real-time, SCINTILLATION DETECTORS

Reference


Introduction

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Mixed field analyser (MFA)

The front panel of the quad-channel MFAx4.3 mixed field analyser is shown in figure 1. The dimensions of the system are 350 mm x 260 mm x 110 mm, weighting 4.6 kg.

Fig. 1. The front panel of the quad channel mixed-field analyzer (model no. MFAx4.3).

Two main distinguishing features of the MFAs

- Real-time PSD at high throughput rates
- Close integration of controllable HV supply per high-speed digital input channel.

Finite-impulse-response (FIR) filter

The MCA software interface now offers a real-time embodiment of a FIR filter. The smoothing effect that this has is beneficial for both human and computer interpretation, in better determining the MCA channel number of the photo peak. The magnitude of the filter can be set at any time whilst acquiring data, and the filtering influence is displayed in real time. The effect of FIR filter is shown in figures 5 and 6.

Applications of system

- The laboratories at IAEA Headquarters, Vienna, Austria.
- The IAEA Seibersdorf Laboratories, Austria.
- The Atominstitut, Vienna, Austria.
- The laboratories at the Karlsruhe Institute of Technology, Germany.
- The Rokkasho Nuclear Fuel Reprocessing Facility, Japan.
- The AREVA MOX fuel manufacturing plant, France.
- The safeguards laboratories at the JRC in Ispra, Italy.