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Field Waveform Digitizer for BaF2 Detector Array at CSNS-WNS

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In CSNS-WNS (White Neutron Sources at China Spallation Neutron Source), BaF2 (Barium fluoride) detector array is designed for neutron capture cross-section measurements with high accuracy and efficiency. Once proton beam collides with the target specimen, neutron will be excited and flight from the target to BaF2 array. The time of flight corresponds to the energy of the neutron. To identify signals from BaF2 crystal excited by which particle, alpha or gamma, pulse shape discrimination technique is usually used according to the ratio of fast and slow components in the signal. Waveform digitization is a valid supporting technology for pulse shape discrimination. To precisely obtain the wave and time information carried by detector signal, and maximally cover the dynamic range of signal, high speed ADC with sampling rate of 1 GSps and 12-bit resolution is used in the readout system for CSNS-WNS BaF2 detector array. The detector array consists of 92 BaF2 crystal elements with completely 4π solid-angle coverage, which results in 92 analog channels for waveform digitization and time of flight measurement in total. High speed, high resolution and large number of channels inevitably lead to the data amount increasing drastically. Traditionally, lower speed or lower resolution is used to relieve the stress of data readout. In CSNS-WNS, besides waveform digitization task, customized field digitizer module (FDM) also measures the time of neutron flight precisely based on the continuous waveform sampling data. Furthermore, to read massive measured data out in real time, FDM is integrated with PXIe interface, a high-speed serial bus. There are total 46 FDM modules in 4 PXIe chassis, which makes the readout system a distributed architecture. Each FDM can support two valid channels for signal digitizing and two high-density DDR3 memories for Ping-Pong data readout. For the purpose of eliminating invalid data and system synchronization, external trigger or clock signal can be fed into FDM through PXIe backplane star bus or micro-miniature coaxial cables from front-panel. Furthermore, considered as a universal waveform digitization platform, with the help of FPGA and waveform digitized data, FDM can also support full digital hardware trigger function, which can make it possible to remove traditional analog trigger cables with dedicated bus from PXIe chassis backplane. FDM with digital trigger mode can simplify the structure of the data acquisition system drastically. To further reduce the pressure of data readout and storage, a real-time data compress algorithm is implemented in FPGA.

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