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## A 32-channel 1-10 GSa/s Flexible Waveform Recording System using the PSEC4A ASIC

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We present a 32-channel data acquisition system using the PSEC4A chip and initial applications as a readout system for neutron detectors at Sandia's Z Pulsed-Power Facility. The PSEC4A is an 8-channel, 10 GSa/s waveform recording ASIC with an analog bandwidth of 1.9 GHz, which also incorporates multi-event buffering to reduce latency induced by close-in-time triggers. In the 32-channel system, four PSEC4As are time synchronized using a common clock delivered from a PLL chip. Triggering can be done using the internal PSEC4A discriminators or via an external input. An optical serial communication link serves as the user interface to the board.

### Summary

The PSEC4A ASIC, as reported at TWEPP-18, was designed and fabricated in 2017 as an upgrade to the PSEC4 waveform sampling chip. The PSEC4 offers 10 GSa/s sampling rates, self-triggering, and high bandwidth, but its scope is limited due to a short 256-sample recording length on each channel. To address this issue, PSEC4A combines the PSEC4 digital circuitry with a new analog design, which allows a larger recording window as well as the option for multi-event partitioning of the analog buffer, while keeping high analog bandwidth.

The 32-channel board uses four 8-channel PSEC4A ASICs, with each channel fed from a high-density Samtec (SEAF8) board-to-board connector that mates to the sensor board. The four PSEC4As are synchronized to the same clock through a PLL/jitter-cleaner chip, which may be referenced to an on-board oscillator or an external clock input. The system uses a low-cost Cyclone-V FPGA for system control and data management. To enable operation in the high-EMI environment at the Sandia Z Pulsed-Power Facility, the board requires significant shielding and an isolated user interface over optical fiber. The PSEC4A board is designed to a compact size of 70mm by 106mm.

The sensor board is composed of an array of fast scintillator/SiPM detectors. The detector array is designed to measure the total flux and arrival time of 2.45 MeV fusion neutrons produced by deuterium-deuterium interactions in a high temperature plasma. The system can be used in either a particle counting mode for low fluence or in current mode for high fluence. The system response will be measured using a neutron calibration end station at Sandia's Ion Beam Laboratory (IBL). This calibration facility uses the IBL's 300-keV Cockroft-Walton generator to accelerate D<sup>+</sup> ions to 175 keV, producing approximately 2.7  $\mu$ A of beam current onto a 2.5- $\mu$ m thick ErD<sub>2</sub> target. The PSEC4A/SiPM system response will be compared with a standard scintillator/MCP-Photomultiplier/transient-digitizer neutron diagnostic. The PSEC4A system is being constructed for use as a compact and modular neutron time-of-flight (nTOF) spectrometer for Magneto Inertial Fusion (MIF) experiments.

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