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Single Photon Counting based on the Fast-Digitizing, High-Resolution WaveDREAM Data Acquisition System

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Many experiments and applications demand high-resolution, fast waveform digitizing. The use of a switched capacitor array (SCA), as employed by the DRS4 Application Specific Integrated Circuit (ASIC), offers significant cost and power reduction compared to a traditional flash analog-to-digital converter (ADC). The WaveDREAM data acquisition system, based on the DRS4 ASIC, allows continuous digitization of analog signals at 120 Mega-samples per second (MSPS) with the possibility to sample a region of interest at a rate of up to 5 Giga-samples per second (GSPS). Since a low-resolution (120 MSPS) version of the input signal is continuously presented to the digital domain, arbitrarily complex trigger logic can be implemented in a field-programmable gate array (FPGA), while retaining excellent timing resolution in the region of interest. The signal-to-noise ratio (SNR) of the system is measured to be 9.3 bit for the 120 MSPS signal and 9.6 bit for the DRS4 readout signal. A Gigabit Ethernet link provides high-speed connectivity from the DAQ board to the backend system. Built-in board-to-board communication and the modular design of the system offer great scalability and flexibility with respect to the number of supported data channels. Timing resolution is of the order of one nanosecond across the entire system, while being significantly better within one DRS4 ASIC. The excellent time synchronization, high channel density, and low power consumption make WaveDREAM well suited for applications in the field of radiation imaging, where a high number of channels and good timing resolution is required.
This work presents the WaveDREAM system and discusses potential applications, including single photon counting, pulse shape discrimination, time-of-flight (TOF) measurements using constant fraction discrimination (CFD), and many more. Measurement results are shown for single photon counting, and implications for future versions of the DAQ system are discussed.

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