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Development of Real-Time Pulse Processing IP Based on FPGA

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With the increasing demands on particle detector signal processing in fields such as high-energy physics, traditional analog or digital solutions struggle to balance performance and flexibility. To address this, this paper develops an FPGA-based real-time signal processing program for particle detectors. The program integrates algorithm modules including signal shaping, pulse triggering, waveform acquisition, zero-cross timing, and pulse amplitude analysis, fulfilling most functional requirements for real-time detector signal processing. Performance-wise, the program suppresses common-mode noise through signal shaping, enhances timing accuracy via linear interpolation, and prevents amplitude distortion through dynamic baseline scanning. Developed using Xilinx's Vivado design suite, the program features flexibly adjustable parameters for each module and unified interface protocols, enabling rapid configuration for diverse application scenarios.Experiments utilized a signal generator to produce gamma waves for functional verification after programming the data acquisition circuit. Results demonstrate: The shaping module effectively eliminates signal common-mode baseline drift; The triggering module achieves accurate triggering without false positives at thresholds as low as 0.3% of the full scale; The timing module delivers high-precision timing measurements; The pulse amplitude analysis module attains high resolution (0.026%@200 mV) while maintaining excellent linearity in pulse amplitude spectra. These outcomes provide a novel solution for online real-time processing of particle detector signals.

Collaboration you are representing

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