Contribution ID: **91** Type: **Poster presentation**

An FPGA-Based High Precision Pulse Width Measurement Time-to-Digital Converter with Time Division Multiplexing Encoder

Tuesday 23 April 2024 12:35 (20 minutes)

High-precision Time-to-Digital Converters (TDCs) play a pivotal role in contemporary high-energy physics experiments where the measurement of time-over-threshold (TOT) of nuclear pulses is essential.
This paper introduces an innovative FPGA-based TDC capable of outputting timestamps for both rising and falling edges. The hit signal's edges initiate two identical segments of clock-like signals, respectively encompassing timing information from the rising and falling edges, which then propagate along the TDL. Employing the proposed Time Division Multiplexing (TDM) multi-edge encoder in a pipeline configuration allows for the meticulous extraction of timestamps from the TDLs status.
In this study, a 4-edge wave union TDC is implemented, demonstrating proficiency in discerning timings for both rising and falling edges. The corresponding root mean square (RMS) precisions for time intervals ranging from 0 to 10 ns are consistently calculated at approximately 5.0 ps. The TDC measurement dead time corresponds to two system clock cycles, and the minimum discernible pulse width is constrained by the upper limit of the FPGA transmitting port. By leveraging the resource-efficient attribute, a 64-channel TDC, possessing equivalent characteristics and an RMS resolution below 10 ps, is instantiated within a single Kintex-7 device. The FPGA logic resource utilization ranges from 30% to 40%, substantiating the proposed TDC structure as notably compact and highly advantageous for the integration of multiple channels in high-energy physics experiments.

Minioral

Yes

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No

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Session Classification: Poster A

Track Classification: Front-End Electronics, Fast Digitizers, Fast Transfer Links & Networks