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P1.37: Multichannel integrated circuit for time-based measurements in 28 nm CMOS

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Recent advances in the design of readout integrated circuits (ROICs), together with improved time resolution in advanced CMOS nodes, open new possibilities for the construction and possible applications of hybrid pixel detectors. The increasing number of designs focusses on providing precise time and energy measurement capabilities for each detected photon. Time-of-Arrival (ToA) and Time-over-Threshold (ToT) measurement has been used in 3-D particle tracking and reconstruction experiments and is useful in various branches of applied science. We present the design and preliminary measurement results of the ROIC prototype designed in 28 nm CMOS technology, which consists of a matrix with 4 × 8 pixels with 50 µm pitch. Each pixel includes an analogue front-end, Vernier TDC, and digital part with configuration register and counters, and can operate in either SPC mode or in energy and time-of-arrival measurement mode using ToT and ToA methods, respectively. The analogue front-end has been optimised for the time measurement use case. It consists of an inverter-based front-end amplifier (FEA), capacitive feedback, and Zimmerman feedback. FEA is AC-coupled to the discriminator. The FEA gain is controlled by changing the feedback capacitance and current in the Zimmerman feedback. The effective discriminator offset is tuned either by changing the number of unit transistors that form its input, or by changing a current setting the threshold level on its non-inverting input. The discriminator output is routed to the logic that controls the ring oscillators. Their frequency is tuned locally using capacitance banks and DACs. The oscillator outputs are passed to the counters, which consist of 37 bits in total per pixel. Pixel has separate power domains for the analogue part, oscillators, and the digital part (the latter two having dedicated deep N-wells). Measurement results show that the proposed offset correction approach results in a 10-fold improvement, while the gain correction uniformity is improved 3.3 times. The oscillator frequency range for which counters operate properly reaches several gigahertz (5 GHz for the examplary pixel). Current work is focused on testing the full ToT/ToA measurement capability for each channel, and results are expected soon. The work was supported by the National Science Centre under contract no. UMO-2017/27/B/ST7/01217.

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