

A Multichannel Low Noise Long-Integration-Time Readout ASIC for Negative Ion Detection

The Time Projection Chamber (TPC) gas detector can measure charged particles' trajectory and energy spectrum. In the negative ion TPC, gas molecules capture ionized electrons right after their production and form negative ions. The TPC can be used in directional dark matter searches. For example, in the Drift IID and NEWAGE experiments, a low pressure 30:10 Torr $\text{CF}_4:\text{CS}_2$ gas mixture and SF_6 gas were used as the detection medium, respectively. The TPC is also applied in Neutrinoless Double-Beta Decay ($0\nu\beta\beta$) experiments, for example, in the NvDEx(No neutrino Double-beta-decay Experiment) using high pressure $^{82}\text{SeF}_6$ gas as the detection medium to measure the $0\nu\beta\beta$ decay of ^{82}Se . These experiments form negative ions and require that the readout ASIC be able to directly collect these slowly drifting ionic charges with time widths of a few hundred milliseconds to a few seconds for the integration of the charges. However, it also integrates against noise, and if the noise is large, the signal-to-noise ratio deteriorates, so the ASIC noise should be small enough. In addition, a large input dynamic range greater than 30 ke^- is available to meet many ion measurement applications without causing output saturation.

In this study, a multichannel, low noise, long-integration-time readout ASIC for negative ion detection is proposed and implemented in 180 nm CMOS technology. The ASIC comprises 18 channel readout circuits, including 16 normal readout channels and two test channels. The chip employs a switched charge-sensitive preamplifier with an external mechanical switch to eliminate the effect of MOS switch leakage current and thermal noise of conventional feedback resistors. In addition, a self-reset system is integrated to provide a trigger signal and a self-reset signal for the switch, which extends the switch reset method. Post simulation shows that the ENC of less than 4.1 e^- with 5 pF input capacitance, an integration time greater than 10 s for the charge signals, a charge-conversion gain of 32.6 mV/ke^- , and an INL of less than 2% over a dynamic range of 32 ke^- . Tests are underway, and the measurement results will be presented at the conference.

Workshop topics

Front-end electronics and readout

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