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Design and performance of GEMROC2 –a readout ASIC for Micro Pattern Gas Detectors

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In the paper we report on development of an Application Specific Integrated Circuit (ASIC), called GEMROC2. Primary application of this ASIC is readout of 10×10 cm2 3-stage GEM detector, however, it can be used for readout of other types of Micro Pattern Gas Detectors.
The ASIC has been designed in 350 nm CMOS process. Its basic functionality and parameters have been evaluated using internal testability functions. System performance has been evaluated in tests of a fully equipped GEM detector module using X-rays. For argon based gas mixture we have achieved energy resolution below 18% FWHM for 5.9 keV line.

Summary

The Gas Electron Multiplier (GEM) detector technology allows building large area position sensitive detectors though 2-D readout of such detectors at high rate is a challenging task. In the paper we report on the design and performance of GEMROC2 ASIC foreseen for high count rate applications of GEM detectors. Primary application of the ASIC is readout of 10 cm by 10 cm GEM detector, however, it can also be used for readout of other types of Micro Pattern Gas Detectors (MPGD).

The GEMROC2 ASIC comprises 64 independent channels, allowing for simultaneous recording of the amplitudes (energy channel) and time (timing channel) of incoming signals. The front-end circuit accepts input signals of either polarity. Thanks to the implemented token-based read out of derandomizing buffers, it also provides data sparsification and full zero suppression. Reconstruction of the hit positions is performed in an external data acquisition system by matching the time stamps of signals recorded in X- and Y-strips. Signal amplitudes are used for finding centers of gravity for clusters of signals on neighboring strips associated with the same detection events. The ASIC can work in one of six gain modes and one of two shaping modes. A wide range of switchable gain allows one to test and use MPGDs with different gas mixtures and different bias voltages resulting in different internal gas amplification factors. In slower mode the maximum count rate is up to 100 kHz per channel while in faster mode it is three times higher.

Like in any front-end circuit for readout of MPGDs input protection against possible random discharges inside active detector volume has been addressed in the design. A standard solution is an input protection circuit built of discrete SMD components. In case of a high density readout with a pitch of the readout strips below 1 mm the very first problem with such a solution is limited assembly area needed for these circuits. The GEMROC2 provides integrated and silicon proven input protection circuits so it can be used without any additional input protection components.

The basic functionality and parameters have been evaluated using the testability functions implemented in the ASIC design. The ASICs were also tested in a fully equipped GEM detector module including physical measurements of X-rays. The tests using electronic calibration signals allowed us to parameterise analogue performance of the ASICs, while measurements of X-rays with GEM detectors confirmed expected functionality and performance of the whole readout system. For Ar/CO2 and Kr/CO2 mixtures, energy resolution below 18% FWHM at 5.9 keV has been achieved. This energy resolution approaches theoretical limit of intrinsic energy resolution of GEM detectors and our measurement results confirm that the noise of the GEMROC2 ASIC is sufficiently low to not contribute to the overall energy resolution.

In the paper critical design aspects of the ASIC will be discussed and detailed test results of a fully equipped GEM detector will be presented.

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