CMOS Technologies in Detector Readout Systems of Modern Particle Physics Experiments

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Abstract

In the times of constantly expanding knowledge of particle physics and the improvement of the large accelerators, increases the luminosity of experiments. Consequently, it requires better detectors and more precise and faster readout systems. Mostly every system contains the Application Specific Integrated Circuits (ASIC) that allow to preprocess particles' signals from specific detector.

The main focus in this research is on the readout system for straw tube tracker detectors, done with collaboration between groups of the Jagiellonian University and AGH University. The detectors are used in two experiments, in future $\overline{\text{P}}$ANDA (Straw Tube Tracker (STT) and Forward Tracker (FT)) and in upgraded HADES (Straw Tracking Stations (STS)), both at the FAIR facility in Darmstadt. The readout is based on the PASTTREC ASIC developed by the AGH University group. Since more than 5000 chips are used in both experiments, the main goal was to prepare the measurement setup for mass tests and qualification procedures. Everything was verified by measurements with the straw tube module and ^{55}Fe source. As a part of this work, also the optimisation of the Front-End Boards (FEBs) containing PASTTRECs was done and one week internship in HADES during beamtime.

The second part of the research concentrates on the development of ASICs for future experiments. In modern systems, not only the information about the signal's amplitude is needed, but also the measurement of time starts to be required. Therefore, the main focus was on developing a Time-to-Digital Converter (TDC) using 130 nm CMOS technology based on 10-bit SAR ADC (Successive Approximation Register Analog-to-Digital Converter). The 8-channel prototype TDC was designed that allows time measurements with configurable resolution from 10 to 100 ps. The aforementioned 10-bit SAR ADC was also part of HGCROC ASIC for HGCAL in CMS experiment designed by OMEGA group from Ecole Polytechnique in collaboration with the CEA-IRFU Institute in Saclay, CNRS from Paris, CERN and AGH UST. The AGH University group was responsible for ADC design, whose measurements and settings optimisation were part of this thesis.