ABSTRACT

Various scale measurement systems are composed of the sensors providing data through the data acquisition system to the archiving facility. The scale of such systems is determined by the number of sensors that require processing and can vary from few up to hundreds of thousands. The number and the type of sensors impose several requirements on the data acquisition system like readout frequency, measurement precision and online analysis algorithms. The most challenging applications are the large scale experiments in nuclear and particle physics.

This thesis presents a concept, construction and tests of a modular and scalable, tree-structured architecture of a data acquisition system. The system is composed out of two logical elements: endpoints which are the modules providing data and hubs that concentrate the data streams from the endpoints and provide connectivity with the rest of the system. Those two logical functions are realised by the base modules called Trigger Readout Board (abbr. TRB) which feature basic functionality: digitization of the signals, communication with other modules and external networks, control and monitoring mechanisms. This set of functions can be extended on the modules via a system of Add-on boards that introduce new features and allows to adapt the platform for various applications.

The key characteristics of TRB based system are: scalable, flexible, extensible and reconfigurable. The scalability of the platform is realized by the hub components, which allow to create tree structures with many layers, each opening new ports for additional endpoints, without reducing the performance of the entire system. The TRB boards are based on FPGAs, which are reconfigurable, programmable logic devices. This approach results in a possible use of the same hardware module for different functions with just a change of the firmware. It also allows to introduce new functionalities over time. Together with the Add-on system, the platform can be relatively easily adapted to various applications and extended with new elements.

The platform was developed inside the HADES Collaboration with significant contribution from the author. The HADES detector was also the largest target application and was used for extensive tests of the system. Several conducted experiments and laboratory tests described in this thesis confirm the design and allow to evaluate the system performance. The platform has also found application in various other systems, one of them being the J-PET medical imaging project also described in this thesis.