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Development of an FPGA-based data acquisition board for a neutron detector

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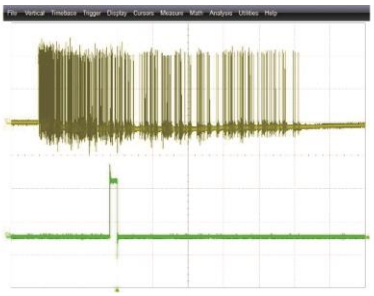
In order to analyze the internal structure of a material, the Paul Scherrer Institute (PSI) performes neutron scattering experiments. Previously, these scattering experiments have been realized with Helium-3 gas detectors. The recent developments in the field of silicon photomultipliers (SiPM) now allow detecting neutrons using so called scintillators. During this thesis, an FPGA-based system for neutron detection was implemented. A 16-channel neutron detection module of the PSI generates the input signals for the system. In the new detection method the scintillators transform energy particles into photons. The combination of scintillators and SiPMs responds to a neutron event with a fast decaying series of pulses. This work has focused on two areas: The detection of the series of pulses in the FPGA and the development of a communication board to the host system.
In order to map the time structure of the pulse sequence, the digitized pulses are counted and stored in periodic time intervals in the FPGA. Due to non-linearities of SiPMs (dark counts, afterpulsing and crosstalk) the digitized series of pulses are not directly interpretable. Therefore, the time of the event is determined through a filtering process and a subsequent maxima finding. Reading and analyzing the pulse sequence is deterministically performed in order to avoid an error in the time measurement. A FPGA controller block has been implemented and is accessible via SPI. This controller allows to configure the parameters at run-time of the detection and analysis process.
For the connection to the host system, a universal communication board with a Spartan 6 FPGA was designed using Gigabit transceivers. Four optical Gigabit links and four standard IOs are placed at the front side of the card. The back side of the board has a modular design for various projects. Optionally, four additional Gigabit links, 48 differential pairs and the system management bus can be configured for the host system.
As a result of the thesis, it could be proven that neutron events can be detected with the new method using scintillators.

The new neutrondetector system



Detection of a neutron