Contribution ID: **34** Type: **Poster presentation**

A Reconfigurable Ethernet-Based Data Acquisition and Processing System for Particle Physics Experiments

Friday, June 10, 2016 10:30 AM (1h 35m)

Nuclear science and particle physics is an important subject in physics, and it is important to launch particle physics experiments in university to train students. The typical characteristic of particle physics experiments is that the detector's output signal is directly fed to the front-end electronics (FEE) of the testing system and after digitization and some preprocessing, the data is buffered and recorded. Various detectors are selected for different experiments, bringing different testing schemes and different data formats. We design a data acquisition and processing (DAQP) system for particle physics experiments in university. By employing digitalization and reconfiguration techniques in our design, we can achieve various instrument functions within only one DAQP board. A variety of detectors can be connected to the DAQP system, and the task of recording and processing the experiment data can be completed easily.

This paper proposes a versatile Ethernet-based DAQP board, so as to get rid of chassis and plug-ins, in the end covering particle physics experiments' requirement. The DAQP system converts the enhancement of the functionality and performance into the development of virtual instruments by using reconfiguration features, making the system retain both the flexibility of software design and high speed of hardware circuit.

Through analyzing the system requirements, characteristics and feasibility of particle physics experiments, this paper presents the hardware architecture of the DAQP system: various kind of small customizable FEE board to accommodate with different detectors' output; multichannel A/D converter for multichannel signal processing; field programmable gate array (FPGA) for data buffering, digital signal processing, command parsing as well as system control; Ethernet chip (iMCU W7100A) to establish network connection between PC and the DAQP system, which can configure the FPGA in passive serial configuration mode. Using FPGA static reconfiguration through passive serial configuration, we can pack a variety of digital functions algorithms into independent IP cores, like single-channel analyzer, multi-channel analyzer, waveform analyzer, pulse shape discrimination (PSD), T/D converter based on tapped delay line and so forth. By modifying the firmware of iMCU W7100A, we can easily establish Ethernet data communication between PC and the DAQP system, which makes it convenient to manage distributed data acquisition system. Developing PC software based on LabVIEW, the system implements the acquisition, display and processing of the experiment data in different types under a friendly GUI.

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Session Classification: Poster Session 2

Track Classification: Data Acquisition