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Data Acquisition Electronics for ^{3}He Position Sensitive Detectors

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ABSTRACT

For high intensity neutron scattering experiments, a new data acquisition (DAQ) system has been developed. A new signal processing electronics (NeuNET) supports fast signal processing, hi-speed data transfer with SiTCP technique, and synchronizing the time information. A new timing processing electronics (GateNET) is satisfied precise timing control for TOF measurements with the NeuNET. Both of these electronics have event-mode data acquisition, which is recording neutron TOF detection as an event. The system enable to a scalable and distributed DAQ system.

1. Introduction

For high intensity neutron scattering experiments, it required fast data processing because neutron-counting rate is increased. Furthermore, neutron pulse-by-pulse counting is expected for new methods of measurements such as observation of transient phenomena by neutron pulse.

As one of the methods of achieving these measurements, a new data acquisition (DAQ) system has been developed in the Materials and Life Science Experimental Facility (MLF) of Japan Proton Accelerator Research Complex (J-PARC). The requirements of neutron experiments, the DAQ system must supports fast signal processing, hi-speed data transfer technique, and synchronizing data processing in each electronics. Intense pulsed neutron beam experiments, detectors such as ^{3}He position sensitive detector (PSD), receive a lot of neutron at the short period, so that quick signal processing is necessary in data processing electronics. With neutron pulse-by-pulse counting, we also named "event mode counting", one event data size is small but the amount of date must be huge, so fast data transfer to next stage, in this case these are PC clusters, must be required. In addition to this, many detectors and signal processing electronics are used in MLF/J-PARC experiments, so simultaneous control of each electronic is important. On the other hand, neutron measurements require flexibility in the experimental configuration, so that ratio of software is increased. We have been selecting the DAQ middleware for MLF experiments. To satisfy above requirements, we have developed a new DAQ system, which consist of a data processing board, a gate timing control board, and other electronics. In this paper, we report the new DAQ electronics system for ^{3}He-PSD.

2. Outline of the DAQ system

A schematic setup of DAQ system is shown in Fig.1. The DAQ system consist of charge pre-amp, pre-amp base-substratum, analog-to-digital converter (ADC) board, data processing board (NeuNET), T_0 gate timing control board (GateNET), network switching hub, and PC. A quantity of each electronics is depending on a number of ^{3}He-PSD, which is used in a spectrometer.

A pre-amp integrate a charge signal from ^{3}He-PSD, and shape a signal pulse for ADC. A pre-amp base-substratum distributes high-voltage to ^{3}He-PSD. A pre-amp test input is also prepared for checking a pre-amp by pseudo signal. A pre-amp and a pre-amp base-substratum are designed for fitting PSD-box which hold several ^{3}He-PSD in one box.

The ADC board and the NeuNET are working together for identifying neutron signal and calculating position in ^{3}He-PSD. For fast data processing, the NeuNET use field programmable gate array (FPGA) logic, and construct processing logic as a hardwired logic. The NeuNET is, then, enabled to treate eight PSD at the same time. Event-mode data-taking is a method of recording neutron detection with the time information as an event, and is one of the characteristic of the DAQ system. Event-mode counting treats a huge data during one neutron pulse cycle, so that the NeuNET has a large memory to buffering the data and equalizing for data transfer. The SiTCP technique is also used in the NeuNET. The SiTCP is fast data transfer electronic which is based on the Ethernet technology [3]. Its maximum data transfer rate is almost limit value of the Ethernet speed. The detail of the NeuNET is described in ref.[1,2].

A time-of-flight (TOF) measurement is an advantage of pulsed neutron experiments. In conventional histogram measurement, TOF base timing of T_0 is simply distributed to each DAQ board. On the other hand, in event-mode measurement, in addition to T_0 timing, the time information is required to make an event data.

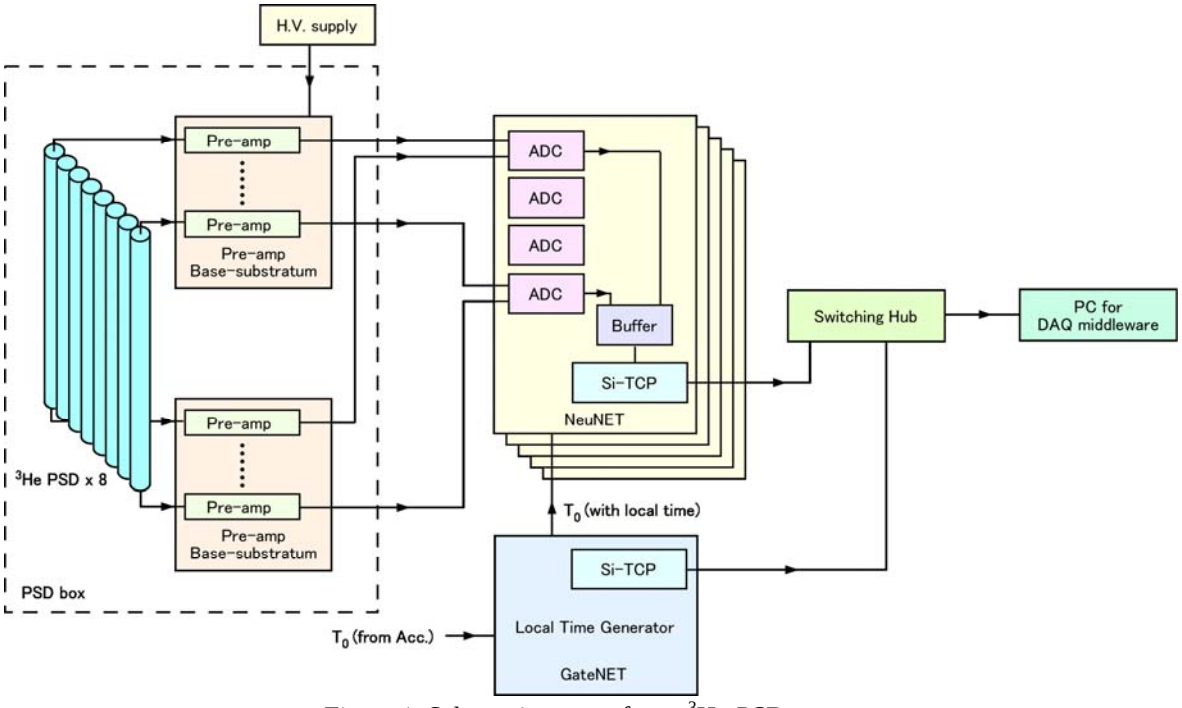

Figure 1. Schematic setup of new ^{3}He-PSD system

The GateNET create the spectrometer's local time and distribute to all NeuNET to synchronize the time information, so that the same time information is used in the whole DAQ system. The time information from the GateNET is superimposed on T_0 signal to decrease signal cable volume. The GateNET also make an event of the time information from T_0 signal. The detail of the NeuNET is described in ref.[4].

Event data are gathering with a network switching hub, then finally stored in PCs by the DAQ-middleware. The DAQ middleware is another key item of event-mode counting, and is described in ref.[5].

Inspection equipments are also devereloped with above electronics. One of these equipments is a pre-amp and ADC tester, which measure a specific characteristic. In case of MLF, one spectrometer use hundreds of ^{3}He-PSD, so that many pre-amp and ADC are used. The ^{3}He-PSD has two outputs in both side of detector, and outputs are connected to an ADC via a pre-amp. It desirable that using almost same characteristic pre-amp and ADC pair in both of ^{3}He-PSD outputs to determine a neutron detection position in ^{3}He-PSD. Another equipment is a PSD system tester, which generate a pseudo PSD signal. Both of these equipments easily make configuration and tuning of the PSD system. Software is also prepared for checking a trouble point in hardware.

The DAQ system is consist of modularized electronics. Therefore, the system has a scalable architecture, which has adapted from a few ^{3}He-PSD to hundreds of ^{3}He-PSD spectrometers. Furthermore, the system is connected by network technology, so that a distributed DAQ system is easily constructed.

3. Summary

The new DAQ system for ^{3}He-PSD has been devereoped. The NeuNET and the GateNET are support event-mode TOF data taking, which is working with the DAQ middleware. Modularized electronics are also enable to a scalable and distributed DAQ system.

4. Acknowledgements

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5. References

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