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Fast multi channel acquisition system without dead time capable to measure oscilloscope-like signals.

Z Dębicki¹, K Jędrzejczak¹, M Kasztelan¹, W Marszał¹, R Nowak², J Orzechowski¹, J Szabelski¹ and P Tokarski¹

⁽¹⁾National Centre for Nuclear Research, Astrophysics Division, Cosmic Ray Laboratory, 28 Pułku Strzelców Kaniowskich 69, 90-558 Łódź, Poland,

⁽²⁾ Lodz University of Technology, Institute of Automatic Control, Control Technology Division, B. Stefanowskiego Street 18/22, 90-924 Łódź, Poland.

E-mail: mk@zpk.u.lodz.pl

Abstract. Within the Baltic Sea Underground Innovation Network (BSUIN) project, we design and build a multichannel signal analysis and acquisition system. Our device can acquire signals from up to 32 detectors at the same time. Each channel has symmetric input, independent adjustable analog trigger, 10 MHz sampling rate, and 10 bits ADC resolution. Micro-controller (μC), FPGA, and micro-processor with Linux allow for different configuration of the system and for preliminary data analysis. In principle the signal's wave-forms from each channel are stored in memory, and a pulse shape analysis can be performed. Independent power suppliers are provided for each channel. We are going to use this measuring system for neutron registration with large number of neutron detectors (helium proportional counters, scintillation neutron detectors, and charged particle scintillation detectors). Especially, measurements of simultaneous measurement of coherent signals from a number of neutron detectors is the purpose for this data acquisition system.

1. Introduction

We want to present electronics that is able to collect the data with a very high degree of scalability in the number of measuring channels. High flexibility in the selection of acquisition parameters allow for optimal operation of connected detectors. Our multi channel acquisition system (photos of the prototype printed circuit boards on the figures 5 and 6) aims to be a universal and cost effective for multi purpose measurements. In particular, we are going to perform measurements at the same time with helium proportional counters, neutron scintillator detectors and with a classical plastic scintillators as well. One common acquisition system gives us consistent measurements with very good time resolution.

2. The BSUIN Project

Astrophysics Division of National Centre for Nuclear Research takes part in a multinational project called „Baltic Sea Underground Innovation Network” (BSUIN) [1]. This project is founded by UE programme „INTERREG Baltic Sea Region”.

The main purpose of BSUIN is to combine underground laboratories (also those less known, and potential locations for underground laboratories, as well) in the Baltic Sea region. The main goal is the development of common standards for the description of the laboratories,



Figure 1. „Baltic Sea Underground Innovation Network” logo (BSUIN)

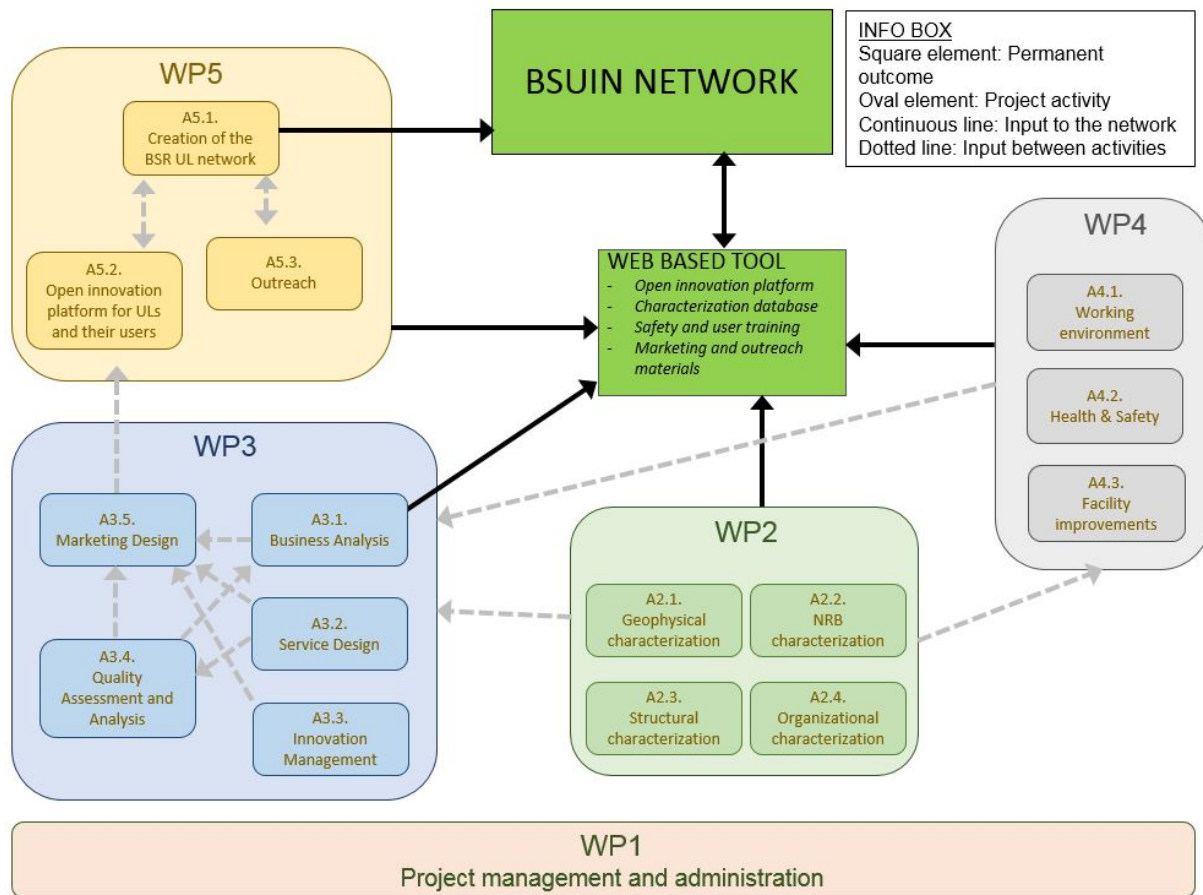


Figure 2. The BSUIN project work packages (WP) scheme. Schematically shown relations between different work packages and the activities. In each of the work packages, institutions from many countries of the Baltic Sea region participate.

security procedures, administration, advertising, etc. This is supposed to facilitate access to laboratories, and thus provide better ones to use. The Łódź group [2] is responsible in the project for the characteristics of the laboratories due to the background from ionizing radiation (indicated within BSUIN as WP2, A2.2, see figure 2), in connection with which we are planning several measurement campaigns in Pyhäsalmi mine [3] in Finland. The BSUIN consortium has 14 members from eight Baltic Sea countries. Six underground laboratories are involved in the BSUIN project.

3. Technical parameters

The biggest advantage of presented acquisition system (see figure 3) is an almost completely dead time free detection of oscilloscope like signals. It is possible due to a signal buffering system (see figure 4) with simultaneous memory Read&Write. Each ADC channel has the differential signal inputs, fully adjustable trigger parameters, the micro controller (μC) and the two regulated power supply units (PSU) for external detector equipment (e.g. ext. High Voltage

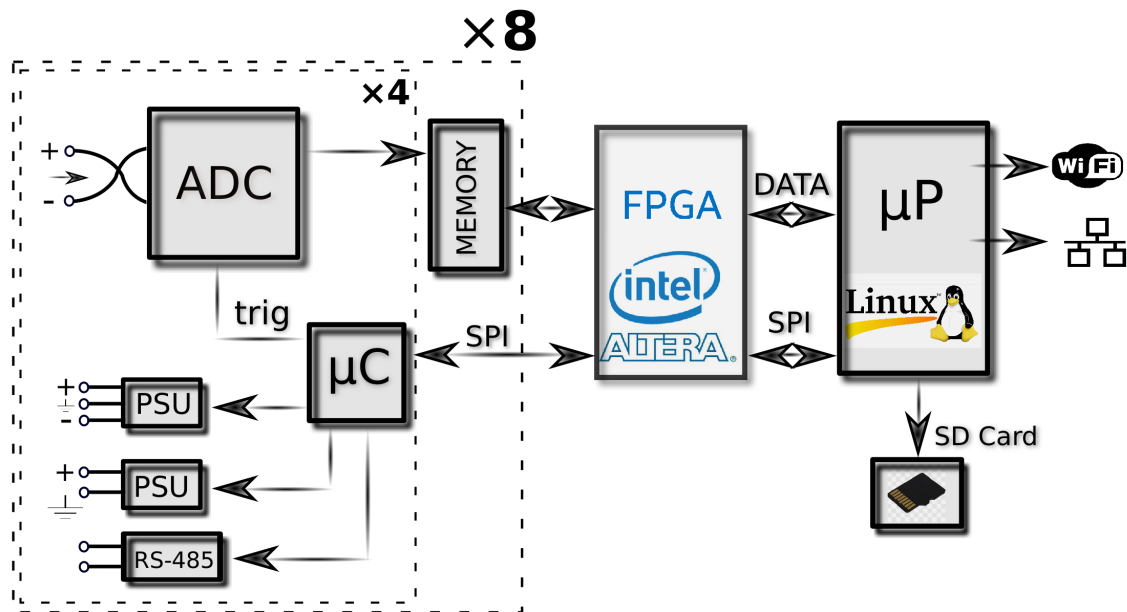


Figure 3. Schematic view of the multi channel acquisition system. On the left there are 8 modules (see figure 5), each with 4 ADC channels. All ADC modules are connected to the mainboard (see figure 6) with Altera chipset and embedded micro processor linux system.

PSU). Each channel can trigger (under independent adjustable conditions) acquisition data from all 32 ADC channels.

The micro processor (μP) system control module (right side of the figure 3) with Linux operating system manages acquisition from all channels and stores data onto built-in flash memory or transfers it to the external PC. The main work management system is based on the Field-Programmable Gate Arrays (FPGA) technology. In this design, the Altera programmable gate system was used [4]. Thanks to this, the modernization of the measurement system is much easier and does not require any hardware modifications. Communication between the μC to Linux acquisition system its done through the Serial Peripheral Interface (SPI) [5].

Table 1. Main technical parameters of the multi-channel analyzer.

ADC Channels	up to 32
Power Supply	2 per channel
ADC Resolution	10 bit
Sample rate	10 MHz (100ns)
FPGA	Altera (Intel)

4. Memory buffer

To store the oscilloscope like signals, we need fast ADC and the memory with low access time. When we aim to store all the data, we need a circular buffer (see figure 4) for each of 32 channels. Each buffer is divided into the several smaller circular buffers, which can be simultaneously written into and read from at the same time with high speed.

The signals are stored online in a series of the circular buffers for each channel. One circular buffer stores 32 samples ($3.2\mu\text{s}$ of the waveform). The signals from one channel can be stored in up to the 4096 circular buffers. When the trigger conditions are met (based on information from all channels) all the signals are stored in the memory. The length of stored wave-forms depends on signals amplitudes, newly emerged trigger signals and the specified time.

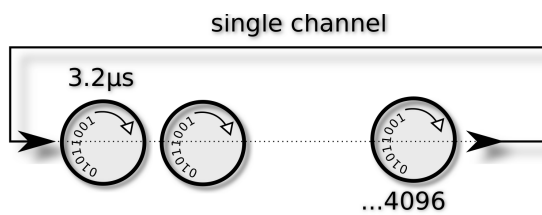


Figure 4. Schematic view of the memory circular buffer. The picture represents buffer for the single acquisition channel.

Writing and reading from each circular buffer is done almost at the same time (odd and even clock ticks), which allows to read data as soon as they are sampled by the ADC.

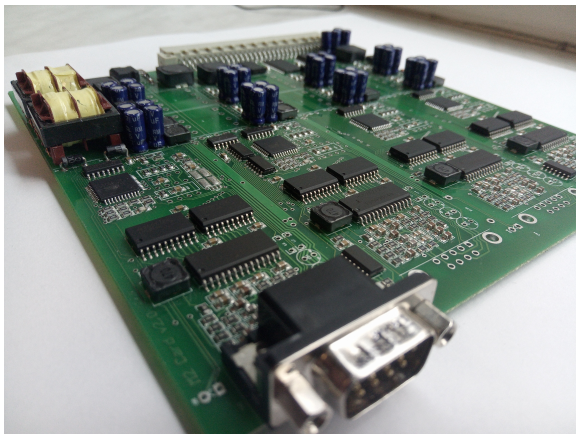


Figure 5. Electronic module with four ADC measuring channels, the micro-controller to control acquisition parameters and the power supplies.



Figure 6. The main-board with Field Programmable Array (Altera) and linux microprocessor system.

5. Summary

The new measurement data acquisition system (see figures 5 and 6) will allow to record the whole wave-forms without (almost) dead time. A large number of the measuring channels allows flexible selection of configurations and types of the detectors used in the measurements.

Differential inputs of the electrical signal from the detectors allow to avoid interference in the signal transmission from the detector to the ADC. Each measuring line has the ability to control two independent external power supplies that can be used to power up the detectors. The triggering parameters of individual data acquisition channels can be set independently in a very flexible way. Thanks to the programmable gate system (FPGA), an easy upgrade of this system is possible. An undoubted advantage is the use of the microprocessor system with its own operating system, thanks to which it is possible to carry out the measurements without an additional PC. It is especially important in locations where access to electricity could be very limited (e.g. in a mine). The low demand for electricity allows the use of a battery-powered power source, which is very important in the mines where the power supply can be very unstable and interfere with measurements.

Acknowledgments

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