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Wide dynamic range acquisition system for innovative radiation detectors

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Wide dynamic range acquisition system for innovative radiation detectors

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ABSTRACT

There is particular interest to develop low-noise and wide dynamic range data acquisition systems for silicon detectors in view of using the same acquisition readout electronics for a wide range of application fields like monitoring and characterization of radiation sources or particle beams. In the framework of a research project for the qualification of Components Off The Shelf (COTS) for their use in space, research groups from INFN-Perugia, INFN-LNS and from MAPRAD have developed a fully automated, remote controllable, wide dynamic range acquisition system for silicon strip or pixelated detectors. Its design and a basic description of the performance are given here.

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1. Description of the acquisition system

The first generation of a multi-purpose front-end and readout system has been designed for silicon-strip detectors but it is easily adaptable also to new generation of radiation sensors such as silicon photomultipliers. The current pulses generated by the sensor are sent to a low-power ASIC (VA32TA2.2) [1] with a

Fig. 2. Positioning system of the detector and DAQ electronics.

Fig. 1. Block diagram of the DAQ system.

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Fig. 3. Cosmic-ray signal measured on the junction side (top) and on the ohmic side (center) of a thick double-side silicon detector. The bottom plot shows the RMS noise on junction side (S side—continuous line) and junction side (K side—dashed line).

32-channels preamplifier and fast triggering stage. The preamplifier circuitry is 32-channel, low-noise, low-power, charge-sensitive preamplifier and shaper, Sample-Hold (SH) circuitry with multiplexed analog readout and calibration capabilities. Each channel of the time unit circuitry consists of one-level sensitive

discriminator with adjustable threshold. Only inputs with pulse amplitude above the threshold yield the trigger. The total dead time of the readout system is about 20 μ s which consists of the granularity introduced by the clock speed and additionally few μ s of veto as safety margin. The dead time can be lowered almost to zero by reading the sensor on both sides and applying proper trigger algorithm on each side. This is particularly important for application where very short time delayed coincident measurements are a major concern.

The DAQ system consists of two boards, one for the p-side and one for the n-side of double-sided silicon detector system. Both the boards process the analog (pre-amplification by the front-end circuitry) and digital signals after digital conversion. The master FPGA stage (clocked at 48 MHz) drives all the control signals of the hybrid (DAC and thresholds settings) and the ADC timing synchronization. A time tag is also assigned to each triggered signal. A separate pure digital board (slave FPGA) stores the data on buffer memories and transfers to the on-board computer (Fig. 1). The data from DAQ is linked to the onboard PC through a USB 2.0 interface.

Unique features of system include adjustable trigger level, the capability, on either detector sides, to use a capacitive dumping board to contain and measure the entire strip charge without saturation of front-end electronics. The power supply system is based on a TCP/IP remote controllable unit which provides the low voltage for the data acquisition system and the high voltage to deplete the sensors. A full custom LabView front-panel was developed for the online monitoring of the sensor and biasing voltages as well as for four parameters (X, Y, Z, θ) positioning control of the detector (Fig. 2). The system performance has been tested at the irradiation facility of LNS-INFN, Catania, and preliminary results have been reported elsewhere [2].

2. Performance of the system

In order to evaluate the performance of the system we have used it in connection with a thick (1.5 mm thickness) double-sided silicon strip detector having 0.5 mm strip pitch (on both sides) and active dimensions 3×3 cm².

We have tested the performance of such a system using cosmic rays, radioactive sources and ion beams at the Catania LNS synchrotron. Fig. 3 shows the cosmic-ray signal on the junction side (top) and on the ohmic side of the detector (center). The bottom plot is the RMS noise performance on the junction side (named S) and ohmic side (named K).

References

- [1] VA32TA2.2 datasheet. Available on request to IDEAS <www.ideas.no>.
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