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Developments on SPIROC family chips (SiPM Integrated Read-Out Chip): Dedicated very front-end electronics for an ILC prototype hadronic calorimeter with SiPM read-out

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SPIROC embeds cutting edge features that fulfil ILC final detector requirements. It has been realized in 0.35m SiGe technology. It has been developed to match the requirements of large dynamic range, low noise, low consumption, high precision and large number of readout channels needed.
SPIROC is an auto-triggered, dual gain, 36-channel ASIC which allows to measure on each channel the charge from one photoelectron to 2000 and the time with a 1 ns accurate TDC.
An analogue memory array with a depth of 16 for each channel is used to store the time information and the charge measurement. A 12-bit Wilkinson ADC has been embedded to digitize the analogue memory content (time and charge on 2 gains). The data are then stored in a 4kbytes RAM.

Summary

The SPIROC chip is a dedicated very front-end electronics for an ILC prototype hadronic calorimeter with Silicon photomultiplier (or MPPC) readout. This ASIC has been produced to equip the 10,000-channel technological demonstrator in 2010 in the frame work of EUDET.

SPIROC is an evolution of FLC_SiPM chip used for the ILC analogue hadronic calorimeter physics prototype. The first prototype (SPIROC 1) was submitted in June 2007. It embeds cutting edge features that fulfil ILC final detector requirements. It has been realized in 0.35µm SiGe technology. It has been developed to match the requirements of large dynamic range, low noise, ultra low consumption, high precision and large number of readout channels needed. Before the production in March 2010, a second prototype which corrects the bugs encountered in the first version was submitted in June 2008.

SPIROC is an auto-triggered, dual gain, 36-channel ASIC which allows to measure on each channel the charge from one photoelectron to 2000 and the time with a 1 ns accurate TDC. An analogue memory array with a depth of 16 for each channel is used to store the time information and the charge measurement. A 12-bit Wilkinson ADC has been embedded to digitize the analogue memory content (time and charge on 2 gains). The data are then stored in a 4 kbytes RAM. A very complex digital part has been integrated to manage all theses features (ADC, TDC and memories control, etc.) and to transfer the data to the DAQ.

This new electronics readout is intended to be embedded extensively in the detector. The most important feature is clearly the reduction of the power consumption. The huge number of electronic channels and the high density of the calorimeter make crucial such a reduction to 25 µWatt per channel using the power pulsing scheme, possible thanks to the ILC bunch pattern: 2 ms of acquisition, conversion and readout data for 198 ms of dead time. However, to save more power, during each mode, the unused stages are off.

After an exhaustive description, the extensive measurement made on the 2 prototypes (SPIROC 1 and SPIROC 2) and the encountered difficulties will be presented.

Moreover, a variation of SPIROC has been used for various other applications which use SiPM detector (Volcanology, Medical imaging, Astrophysics, Nuclear physics, etc.).

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