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SPACIROC2: A Front-End Readout ASIC for the JEM-EUSO observatory

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The SPACIROC ASIC family is designed for the JEM-EUSO observatory onboard of the International Space Station (ISS). This rad-hard ASIC is proposed for reading out the 64-channel Multi-Anode Photomultipliers which will equip the detection surface. Two main features of this ASIC are the photon counting mode for each input and the charge-to-time conversion for the multiplexed channels.
SPACIROC1 was submitted in 2010 and showed global good behavior. A second version of SPACIROC has been designed to fix bugs and improve global consumption. Design and the test results of SPACIROC2 are presented in this paper.

Summary

The primary purpose of JEM-EUSO mission is the detection of the Extensive Air Showers (EAS) created by the Extreme Energy Cosmic Rays (EECR >10ˆ19 eV), inside the atmosphere.

Multi-anode photomultipliers (MAPMT) are proposed to be the sensitive device of the telescope's focal surface. SPACIROC2 was designed to accommodate the readout of these MAPMTs. For this mission, the ASIC is required to count detected photons and to perform charge to time conversion. SPACIROC2 offers 64 inputs dedicated to the anodes of one MAPMT.

The specifications for the chip are the following:
- 64 channels preamplifier with independent gain (8-bit) adjustment.
- Photon Counting : 64 channels.
- Q-to-T converter : 8 internal channels (multiplexed inputs).
- 100% trigger efficiency for charge greater than 50fC (˜1/3 p.e.).
- Q-to-T converter input range: 2 pC –200 pC (13 p.e –1250 p.e.).
- Power consumption : 1 mW/channel.
- 9 data serial outputs.

The input signal passes through a low-noise and low input impedance preamplifier with an individual variable gain of 8-bit. Afterwards, the amplified signal could be fed through shapers or into the Q-to-T converter. Currently, the chip offers 3 different discriminator outputs for discriminating the detected photons. Depending on the selected shaper and discriminator, this chip could reach a double pulse resolution up to 20ns. To count the detected photons, a digital module was built for each channel around an 8-bit counter which could operate up to 100 MHz. At the end of each acquisition window (GTU=2.5µs), the counter values are transmitted through 8 serial links.

As mentioned earlier, the 8 inputs of the Q-to-T converter will take the pre-amplified signals from the photon counting (sum of every 8 channels). An impedance converter and a charge integrator are used to transform the input signal into a voltage signal. A network of capacitors is used to integrate the input signal. Later, a variable length discriminator output is obtained by comparing the integrated pulse to an adjustable reference value. Adjusting this discriminator pulse width is simple: it is done via a variable gain current source. Finally, this discriminator output will be sampled by a 40MHz clock. In a similar manner to the photon counting readout, the discriminator length data are sent through a serial link at the end of each GTU.

Several precautions have been taken to make sure SPACIROC could operate in extreme conditions. For instance the layout was done carefully in order to minimize the Single Event Latchup effect. A mechanism to detect Single Event Upset was also added. The design was done using AMS SiGe 0.35µm process. The final chip dimensions are 4.6 mm x 4.6 mm. The ASIC was submitted for fabrication in November 2011 and a batch of 5 packaged ASICs arrived in February. Extensive laboratory tests for characterising the ASIC are currently underway. The preliminary results have shown that the ASIC is working and exhibits a good behaviour.

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