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Digital Part of SPIROC : SiPM Integrated Read-Out Chip for ILC hadronic calorimeter

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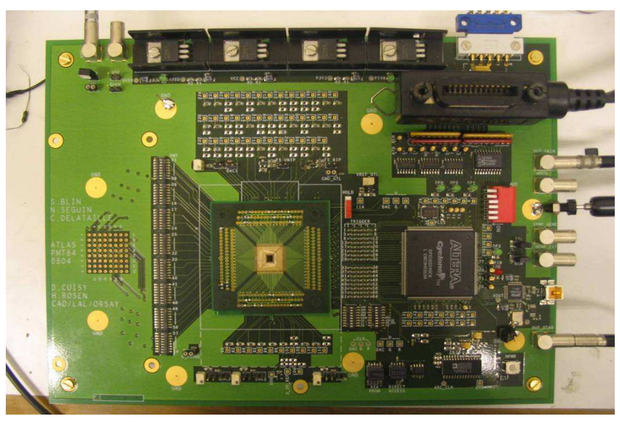
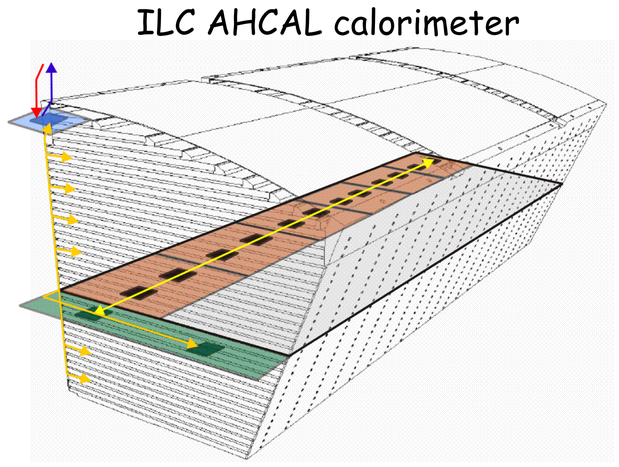
SPIROC Test Board



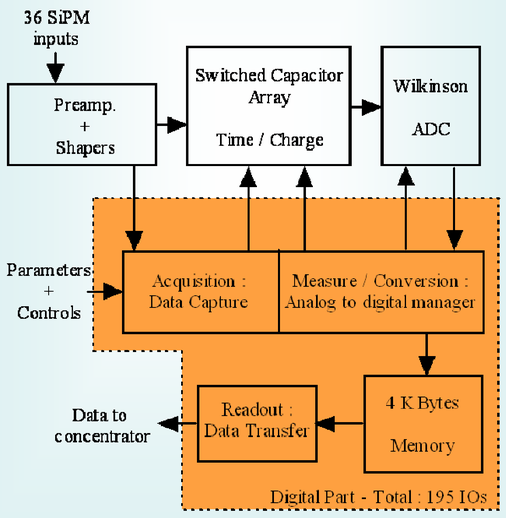
- 36 SiPM inputs can be read by 1 chip SPIROC
- Depth of 16 for charge and time measurement
- ADC accuracy adjustable from 8 to 12 bits by Slow Control
- Bunch Crossing ID, Hit channels and Gain saved for each column of Switched Capacitor Array (SCA)
- 4K bytes of embedded memory
- 2 clock domains for digital part : 40 MHz and 5 MHz / 1 MHz
- AMS 0.35µm standard digital cells

ILC AHCAL calorimeter



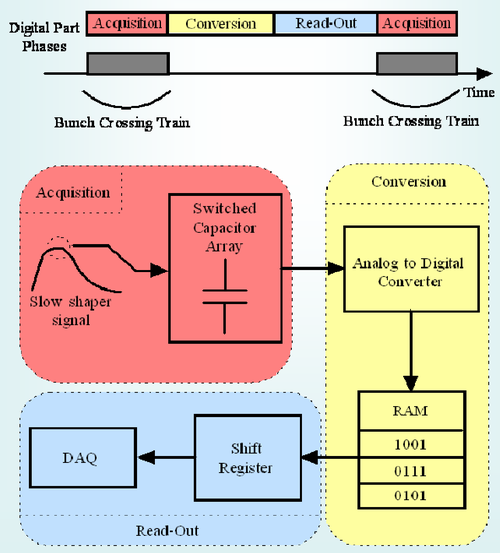
Block diagram of the chip

SPIROC is the readout chip designed for the hadronic calorimeter of the future ILC. It reads 36 SiPMs (Silicium Photo-Multipliers) and has an auto-trigger on its 36 channels. The digital part manages all the different steps of normal working (acquisition, measure and read-out).



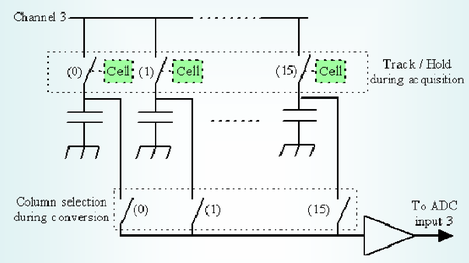
High Level working

The digital part of SPIROC is built around 3 modules (Acquisition, Conversion and Read-Out) which represent the different steps of the ILC working. The acquisition module permits to capture data during the bunch crossing train. Conversion and Read-Out ones are activated during inter bunch crossing to convert and save data in the memory in a first step and to read out data in a second one to the concentrator (DAQ).

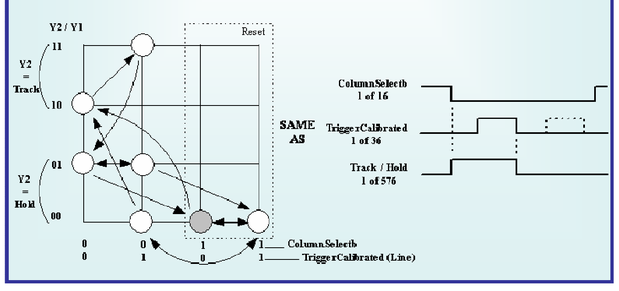


Detail of a SCA channel

The chip has 36 channels. Each channel has a depth of 16 for charge and 16 for time storage. The column is selected by the digital part.

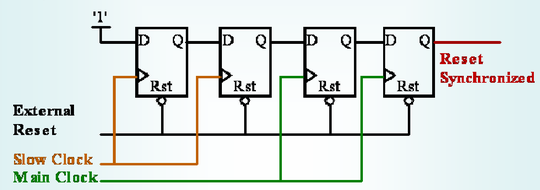


"Track & Hold Cell" allows to lock the capacitor value only when a calibrated trigger occurs within the selected column.

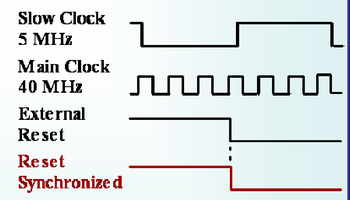


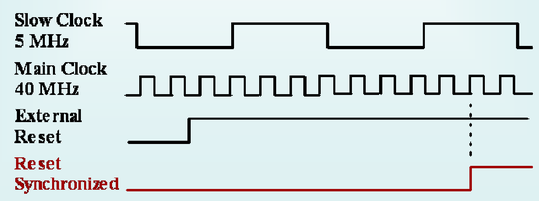
Master Reset

General Reset of the digital part is active low and synchronous with rising edge of Main Clock. It is active for the 2 clock domains (Slow Clock and Main Clock).
To prevent timing violation when Reset is released, it must be synchronised with the 2 clock domains.



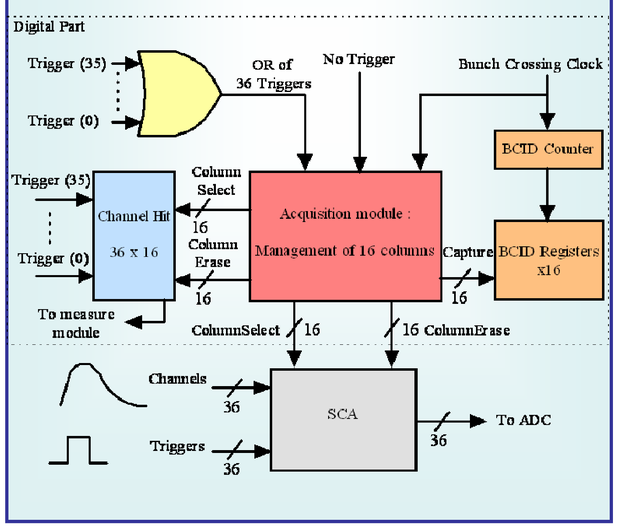
This circuit insert a latency when Reset is released (start of digital part). Latency is equal to 2 periods of Slow Clock + 2 periods of Main Clock (450 ns with 5 MHz and 40 MHz).



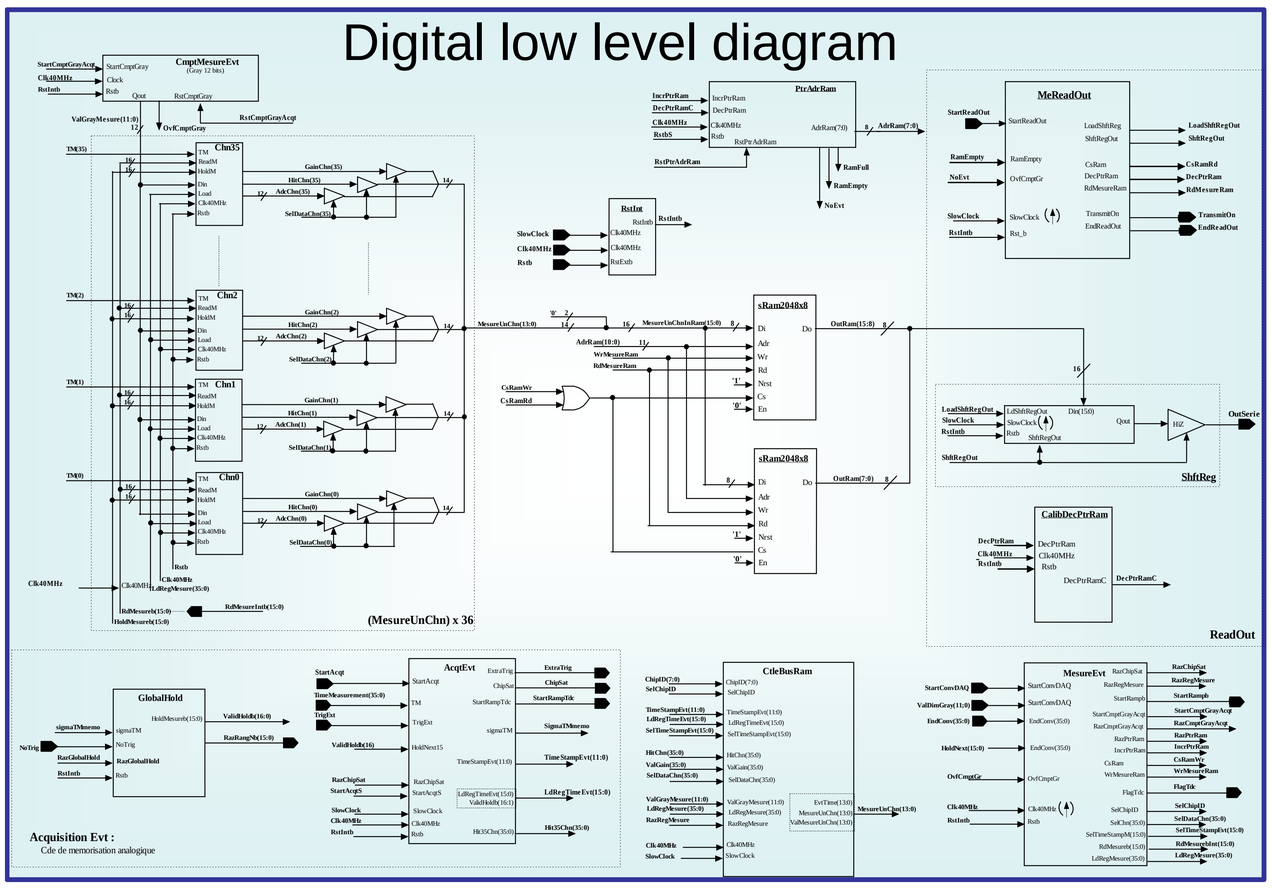


Detail of Acquisition

During idle mode, a capture window is open at the first empty column of SCA (depth 16). When a trigger occurs, data can be captured in this column by means of a "Track & Hold Cell". When next bunch crossing occurs, it closes the capture window and selects the next column.
The Bunch Crossing Identifier (BCID) and all hit channels are also saved into registers.
For this module, only Slow Clock (Bunch Crossing Clock) is needed.

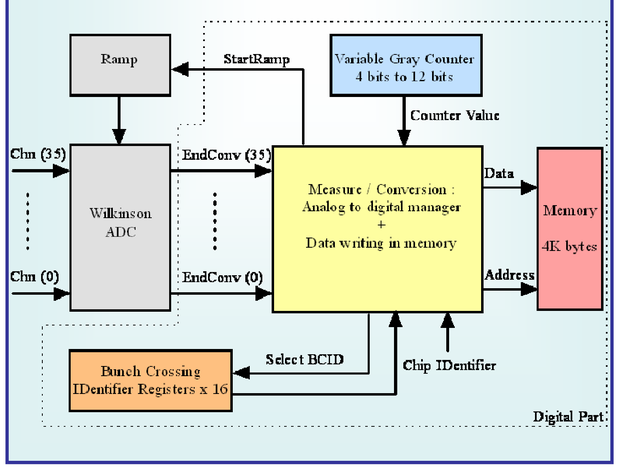


Digital low level diagram



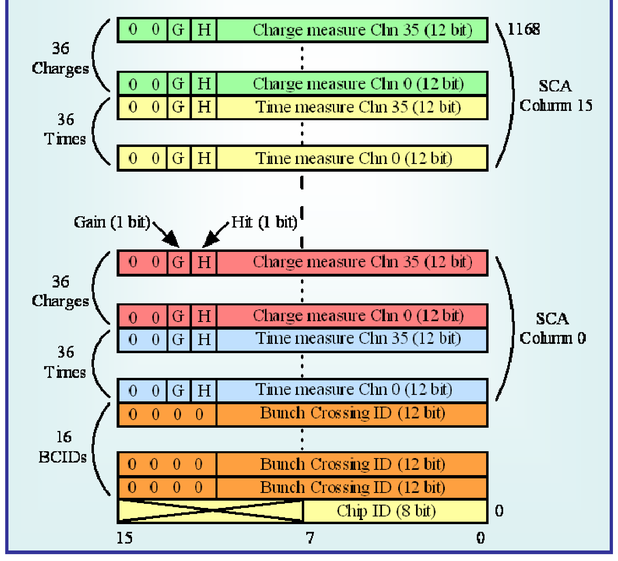
Detail of Conversion

The main purpose of this module is to convert analogue values stored in the SCA in digital ones.
36 charges and 36 times stored in SCA must be converted for each column. When these 72 conversions are over, data are stored in the memory in order to start a new one for next column.
ADC is able to convert 36 analogue values in 1 run (about 100 µs @ 40 MHz). If SCA is full, 32 runs are needed.
As the default accuracy of 12 bits is not always needed, the number of bits of the counter can be adjusted from 8 to 12 bits.

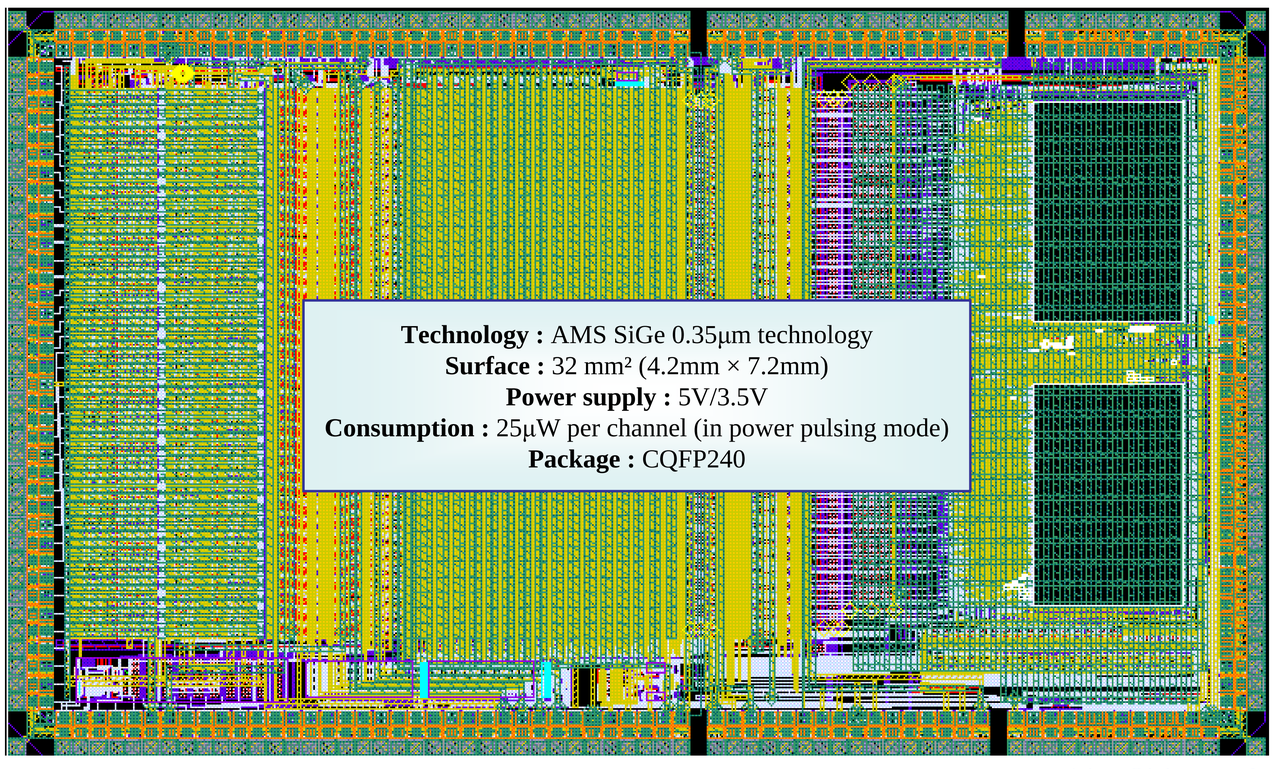


Detail of Read-Out

The Readout module permits to empty the memory. To minimize lines between board and external concentrator, data are transferred on a single line.
In the worst case, about 20K bits of data are transferred to the concentrator with a 5 MHz clock. As the data line to the concentrator is common to all the daisy-chained ASICs, one ASIC can take the data line for a maximum of 4 ms.
Slow Clock and 40 MHz are needed respectively for data and RAM access.



SPIROC Full Chip layout



Technology : AMS SiGe 0.35µm technology
Surface : 32 mm² (4.2mm × 7.2mm)
Power supply : 5V/3.5V
Consumption : 25µW per channel (in power pulsing mode)
Package : CQFP240

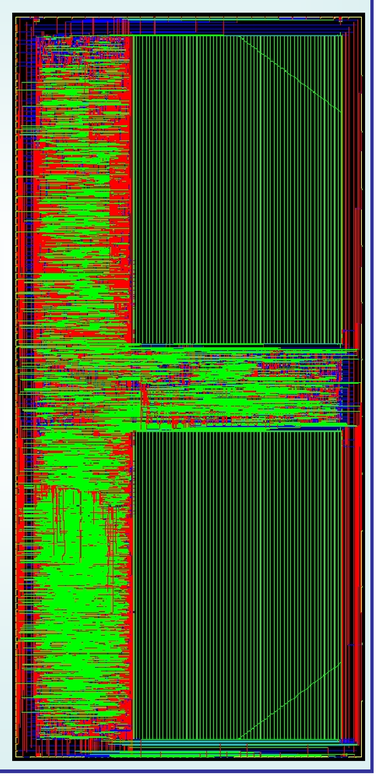
Digital part Layout

The layout of the digital part was realized in 0.35 µm technology from Austria Mikro System (AMS) and designed with Silicon Ensemble 5.4 from CADENCE.

The layout is on 3 metals (blue, red and green) and its size is 3000 µm by 1400 µm.

The layout is made around 2 RAMs from AMS.

Each RAM is 2K bytes (2048 words of 8 bits) and 844 µm by 1250 µm



http://www.in2p3.fr/actions/electronique/microelectronique.htm
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