Contribution ID: **107** Type: **Oral**

Design of the analog front-end for the Timepix3 and Smallpix hybrid pixel detectors in 130nm CMOS technology

Tuesday, 24 September 2013 15:40 (25 minutes)

This front-end contains a single-ended preamplifier with a structure for leakage current compensation, suitable to both signal polarities. Preamplifier and discriminator are required to be fast, to allow a Time-of-Arrival measurement with a resolution of 1.56ns. Time-Over-Threshold (TOT) is also measured; the monotonicity of TOT with respect to the input charge is greatly improved as compared to the previous Timepix chip. The analog area is only 55um x 13.5um.
The design of the front-end, the main features of the chips and the first measurements are presented.

Summary

An analog front-end for the Timepix3 chip has been designed and submitted. This same front-end is used also for the Smallpix chip, under development, and serves as a basis for the future Velopix chip, meant for the LHCb upgrade.
Among the applications for Timepix3 are readout of gaseous detectors (TPC), particle tracking in HEP, and dosimetry. Additionally, Timepix3 will be also extensively used in the power pulsing tests for the future Linear Collider.
Timepix3 is a 256x256 array of pixels with a pitch of 55um. Each pixel provides simultaneously 18-bit Time-of-Arrival (ToA) and 10-bit Time-Over-Threshold (TOT) measurements. The chip can be read out in a 0-suppressed data-driven mode with an expected maximum rate of 40Mcps/cm^2.
The front-end contains a single-ended preamplifier, followed by a three-stage discriminator. A 4-bit current-mode DAC in each pixel corrects the pixel-to-pixel threshold mismatch by adding different currents to two differential branches of the discriminator.
The preamplifier uses a Krummenacher feedback [1], and can therefore handle signals of both polarities and compensate for their leakage currents. Since the measured quantity is TOT rather than preamplifier output amplitude, the feedback capacitance is as small as 3fF, and the output is already in saturation for incoming charges larger than 14ke-. Some modifications to the feedback network have been introduced to improve the TOT response for large positive charges (>100kh+); the TOT monotonicity with respect to the input charge is now much improved as compared to the previous Timepix chip [2]. The TOT saturates for negative charges larger than 150ke- or positive charges larger than 500kh+.
The available area is only 740um^2, due to the 55um pixel pitch and the massive digital functionalities included on-pixel. The pixel capacitance is expected to be in the range 25-50fF. The input pad sits on top of the digital part of the pixel; studies and simulations have been carried out to quantify and minimize the noise injection into the sensitive analog nodes.
In Timepix3, an internal clock running at a frequency of 640MHz sets the requirement of 1.56ns for the ToA resolution. Therefore, the analog front-end offers jitter and pixel-to-pixel timing mismatch below 1ns. This resolution targets gaseous detector applications.
Power pulsing features are added to the chip. Analog biasing is generated in the chip periphery, which can switch dynamically the front-end to a low-power state, implementing power pulsing cycles. Clock gating avoids digital switching power consumption during the off period of the power pulsing cycle.
The design of the front-end is presented together with the first measurements from Timepix3, which is expected back from the foundry in July.

[1] F. Krummenacher, "Pixel detectors with local intelligence: an IC designer point of view,"NIM A305, 1991.

[2] X. Llopart et al., “Timepix, a 65k programmable pixel readout chip for arrival time, energy and/or photon counting measurements,”NIM A581, 2007.

Primary author: DE GASPARI, Massimiliano (CERN)

Co-authors: ALOZY, Jerome Alexandre (CERN); CAMPBELL, Michael (CERN); VALERIO, Pierpaolo (Universita e INFN, Roma I (IT)); BALLABRIGA SUNE, Rafael (CERN); POIKELA, Tuomas Sakari (University of Turku (FI)); WONG, Winnie (CERN); LLOPART CUDIE, Xavi (CERN)

Presenter: DE GASPARI, Massimiliano (CERN)

Session Classification: ASICs