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CITIROC : a new front-end ASIC for SiPM read-out

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Citiroc is a 32-channel front-end ASIC designed to readout silicon photo-multipliers (SiPM).
Citiroc allows triggering down to 1/3 pe and provides the charge measurement with a good noise rejection. Moreover, Citiroc outputs the 32-channel triggers with a high accuracy (100 ps).
An adjustment of the SiPM high-voltage is possible using a channel-by-channel DAC connected to the ASIC inputs. That allows a fine SiPM gain and dark noise adjustment at the system level to correct for the non-uniformity of SiPMs.
Timing measurement down to 100 ps RMS jitter is possible along with 1% linearity energy measurement up to 2500 p.e. The power consumption is about 2mW/channel, excluding ASIC outing buffer

Summary

Citiroc is a new ASIC designed by Weeroc, a start-up company from the Omega microelectronics group of IN2P3/CNRS.
Each channel of this new ASIC embeds a front-end read-out chain composed of two AC-coupled voltage low-noise preamplifier with variable-gain adjustment. The utility of the gain tuning on the preamplifiers is twofold. On the first hand it allows to compensate non-uniformity between channels by finely adjusting gain channel by channel, on the second hand, it allows to adjust the general gain of the amplification chain to adjust the read-out chain to the SiPM gain, allowing a large choice of SiPM on the system to be used.
Citiroc has a new channel-by-channel trigger chain composed of a fast shaper followed by two discriminators with individual channel-by-channel threshold adjustment to be able to trig on the first photo-electron and validate the trigger on the first few photoelectrons. That double trigger allows a great dark noise rejection at the first stage of the read-out chain and avoids saturating the DAQ with noise events. Each trigger channel can be masked in case of noisy channel, latched, or output the discriminator output as is depending on user needs. A general ASIC trigger is also outputted through a 32-input trigger OR.
Citiroc energy measurement is composed of two variable-gain shapers to get energy measurement from one to 2500 photoelectron with 1% linearity. Charge proportional to energy can be stored in an analogue memory using either an analogue memory or a peak-sensing detector to get rid of the hold signal versus trigger delay.
A channel-by-channel input DAC allows adjusting the high voltage of the SiPM over 5V with 8-bit resolution to correct for SiPM over-voltage non-uniformity.
Citiroc outputs 32 trigger outputs as well as a multiplexed tri-state hit-register to allow several Citiroc to be serialized on a single hit-register serial bus. Citiroc outputs two multiplexed analogue outputs to read-out the charge on both low and high gain to ease the low-gain and low-gain channel inter-calibration.
Citiroc also embed a general 10-bit DAC for coarse general threshold adjustment. Voltage references in the ASIC are done with a bandgap to improve power supply rejection ratio and temperature sensitivity of the ASIC. Citiroc is aimed to be mounted very close to the SiPM in the systems it will be used in. A temperature sensor has been embedded to allow users to finely sense the temperature within their multi-channel system to correct for SiPM gain over voltage adjustment with temperature.
As a conclusion Citiroc has been designed to be as versatile as possible for SIPM read-out. It is aimed to be used in large system and has been optimized to ease the SiPM adjustment and reduce has much as possible

the data flow through the DAQ by filtering the SiPM noise at the front-end level.
Citiroc will be used in a first telescope prototype for the CTA experiment and is aimed to be used in medical systems such as PET or gamma cameras using SiPM. A test board with ergonomic GUI software is available for Citiroc evaluation.

Authors: DE LA TAILLE, Christophe (OMEGA/IN2P3); Dr MARTIN CHASSARD, Gisele (OMEGA/IN2P3); FLEURY, Julien (Weeroc); Mr RAUX, Ludovic (OMEGA/IN2P3); Ms SEGUIN-MOREAU, Nathalie (OMEGA/IN2P3); AHMAD, Salleh (Weeroc SAS); Mr CALLIER, Stéphane (OMEGA/IN2P3)

Co-author: CATALANO, Osvaldo (INAF)

Presenter: AHMAD, Salleh (Weeroc SAS)

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