

XXXIII Cycle

Analog Integrated Electronic for DarkMatter Detector under Cryogenic Alejandro D. Martinez Rojas Supervisor: Prof. Angelo Rivetti

Research context and motivation

Darkside-20K is an experiment for demonstrating the existence of the Dark Matter. The idea is to search the particle called Weakly Interacting Massive Particles (WIMPs). These particles arrives from the Dark Matter halo. It produces the WIMP-nucleus elastic collisions. These can be detected on the Earth due to its high energy.

This Astroparticle project should detect these particles using a Liquid Argon Time Projection Chamber (Lar TPC). The chamber is deployed in a Veto structure with a spherical Liquid Scintillator Veto (LSV) to reject, with high efficiency, neutrons and gamma, which induced wrong



Addressed research

Design a pre-amplifier capable to readout SiPM tile of 24cm² with a low noise and low time jitter considering the large sensor capacitance of 8-9 nF, and a temperature of 77 K. Furthermore, the output signal should have a SNR higher than 8 to perform a good discrimination.

The circuit is designed in 110 nm CMOS technology. This technology work properly under cryogenic condition of 77K. The electronic design is based on reducing the hot carrier probability.



events.

An event inside the TPC can be produced by electron and nuclei recoil. These release energy within the Liquid Argon, a direct excitation is generated producing a fast scintillation signal (S1).

remaining electrons The free Of recombination are accelerated by an electric field up to be extracted from liquid Argon, the electrons excite the Argon gas and generates a secondary scintillation signal (S2). It is used to determine the 3D position of S1.

Adopted methodologies

The top of TPC is composed, up to cover it completely, by arrays of 24cm² SiPM tile. In order to readout the SiPM sensor, a front-end electronic has been designed and produced, using a Trans-impedance amplifier designed in a OTA Folded cascode architecture. Furthermore, a single-ended to differential converter to generate a differential output. This will be connected to optical transceiver.

• Single-ended and differential output available (s.e.-

Novel contributions

The second version of test-chip (pre-amplifiers) was tested under two different conditions (300K and 77K) successfully.



Test chip of Pre-amplifier







The previous circuits were designed to work under cryogenic temperatures. Design techniques were applied based on single transistor tests. The tests were done at 77 K to analyze and compare the parameters I_{on} , I_{off} , V_{th} , G_m/I_d with to simulation and at 300 K.

Submitted and published works

- > Martinez, A., 4-Channel Front-End Integrated Circuit For Readout of Large Area of SiPM *under Liquid Argon*, PRIME 2019 – 15th Conference on Ph.D Research.
- > Martinez, A., Front-End Integrated Circuits For Readout of Large Area SiPMs at cryogenic *temperature*, MOCAST 2019 - 8th International conference.

Future work

- To test the front-end electronic with the last version of the target sensor. The results will ● define the electronic design as a possible final version to implement in the VETO system.
- Study and design a digital filter on-chip, the digital signal processing will be useful to improve the SNR.

List of attended classes

- 01LCPIU–Experimental modeling: costruzione di modelli dati sperimentali (16/4/2018,6)
- 02IUGKG II metodo Montecarlo (11/6/2018, 6)
- 01RGBRV Optimization methods for engineering problems (13/6/2018, 6)
- 03QRHRV Microelectronics for radiation detection II (/3/6/2019, 5)
- 01QORRV Writing Scientific Papers in English (21/2/2019,3)
- Semiconductor detector course ICCUB (7/7/2018, 6)
- Low Power Analog IC design MEAD education EPFL (28/6/2019, 6)
- Introduction to Analogue IC design, Simulation, Layout and Verification EUROPRACTICE RAL (3/4/2019, 4)
- VHDL Language and Design Flow EUROPRACTICE IMEC (27/9/2019, 6)







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