Design d'ASIC analogique pour la médecine nucléaire

Spécialité Microlélectronique

Niveau d'étude Bac+5

Formation Ingenieur/Master

Unité d'accueil

Candidature avant le 07/06/2018

Durée 6 mois

Poursuite possible en thèse non

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Résumé

Le but du stage est de définir l'architecture électronique optimale pour lire des détecteurs dans le cadre de la détection/localisation de faisceaux de protons. Une fois l'architecture définie, le stagiaire devra commencer la conception du circuit intégré multi-canaux réalisant l'architecture établie dans la première phase du stage. Ce stage pourrait être suivi d'un poste de CDD de 18 mois.

Sujet détaillé

Internship position
6 months.
Analog ASIC Designer

Design of an ASIC for the readout of beam profiler detectors for nuclear medicine.

The Institute of Research in the Fundamental laws of the Universe, IRFU, CEA University Paris-Saclay, is an internationally recognized major actor in the fields of high energy physics, nuclear physics, astroparticles and astrophysics. IRFU contributes notably to the ATLAS, CMS and ALICE experiments at CERN. The microelectronics group has a thirty-year experience in low noise ASIC design for particle detectors for space, particle physics and nuclear physics research. The group involves 7 permanent research engineers, 1 post-doctoral researcher and 2 PhDs. The main field of expertise are multi-channel design for low noise front-ends, analog memories, monolithic active pixel sensors, ultra-cryogenic electronics and pico-second timing. The group has more than 400 000 channels operating worldwide and more than 130 000 ASICs on different experiments around the world.

In the context of its research program on new readout systems for beam profiler for nuclear medicine, IRFU opens an internship in microelectronic design for 6 months.
Context

The whole project involves a consortium of research labs leaded by the Laboratoire Leprince Ringuet (LLR) lab at

École Polytechnique, Palaiseau France.
The project aims at realizing a fully working ultra-thin monitor prototype able to permanently operate on mid-energy charged particle accelerators. The targeted beam intensity ranges from a fraction of pA to about 10 nA. The active part of the prototype is built using thin film techniques and low noise electronics provides the readout. The development was initially motivated by the proton therapy needs, but the large flexibility of the techniques employed opens a range of applications that goes well beyond the medical needs.
The project will proceed in four main stages. Signal generation studies, radiation hardness of the active part of the detector, design of the low-noise integrated electronics, realization and assembly with the optimized detector. The final system performance will be studied in real operation conditions with proton, deuteron and alpha beams. The project aims at proposing a patent on the technology developed. IRFU is responsible for the design of the low noise integrated electronics.
Description of the main tasks

The final task aims at designing an 8-channel low noise ASIC for the individual readout of the strip signals of the detector. It has to provide a high dynamic range (>5 decades) and the ability to read very low currents to address the sub-pA to 10 nA beam current range. The task during the internship is to select the best architecture for the ASIC and then to build the first building blocks for the final ASIC.

Step 1: Architecture definition
There are several architectures that have already been identified. Considering the main inputs linked to the application (technology, radiation, dynamic range, low threshold, noise…), these architectures will be evaluated to find the most relevant one.

Step 2: Design of building blocks
After having defined the whole architecture of the chip, the design can begin: schematic design, simulation, layout design, post-layout simulation.

Functionality and associated difficulties
The basic function of the ASIC is a multi-channel femto-ampere meter: each processing channel must convert the incoming current into a voltage with a comfortable conversion factor in order that it can be encoded by a standard possibly distant ADC.
The main difficulty comes from the potential high input dynamic range of more than 5 decades and the very low floor current that we want to measure (in the sub-pA range).
The architecture of the channel will be optimized to the input parameters linked to the detector itself and to the beam in which it could be used. Several key parameters that will strongly influence the design of the channel are: the capacitor of the detector, the number of measurement available (single snapshot measurement or averaging) and the frequency structure of the beam: pulsed, continuous, quasi-continuous.

Scaling
The readout ASIC will be made of 8 identical channels at least.
Each ASIC input channel will be connected to an individual channel of the detector.
In addition, the feasibility of integrating an internal trigger stage (one per channel) will be considered. This would make the beam profiler system independent of the beam electronics. The ASIC, thanks to a tunable threshold, would be able to detect the presence of the beam, and to send a flag.

Mots clés

ASIC, low noise, nuclear medicine.

Compétences

Full ASIC design CAD tools. Cadence.

Logiciels

Design of an ASIC for the readout of beam profiler detectors for nuclear medicine.

Summary

The goal of this internship is to define an optimized electronic architecture to read detectors for beam profilers. The second task is the beginning of the design of a multi-channel ASIC that realizes the main functions defined during the first step of the internship. The internship could lead to an 18 months position to build the whole ASIC.

Full description

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Softwares