"Doctoral Day" Programme
25 June 2020
Opening Session

Date and time: Thursday 25 June, 10:00
Venue: Virtual Room in University of Seville's online platform `ev.us.es`

TIME IS IN OUR SIDE: REFLECTIONS REGARDING TIME AND ITS ROLE IN MICRO-ELECTRONICS

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Abstract:The seminal book of James Clerk Maxwell, "A Treatise on Electricity and Magnetism", first published in 1873, described how to emulate a resistor by using one capacitor and a set of switches controlled by a clock signal. This way, the resistance value happens to be directly proportional to the period of the clock, and inversely proportional to the capacitance. Roughly one century later, in the 1980s, this idea was a keystone for the accurate and robust implementation of miniaturized, sophisticated systems using micro-electronic circuits and technologies. This Maxwell's idea underlies the operation of high-fidelity audio reproduction systems, high-speed wireline communication modems, high-resilience automotive sensors, and high-resolution image sensors, among many other ITC wonders.

The main asset of Maxwell's idea emerges when one comes to the implementation of systems described by differential equations, as it is the case for most front-ends of modern micro-electronic systems. The operation of these systems as signal processors is controlled by time constants, which are primarily defined by the products of resistances and capacitances values. Because resistors and capacitors are fabricated using uncorrelated processes, RC products are subjected to large errors. However, switched-capacitors replace resistors, following Maxwell's idea, the time constant values happen to be proportional to time, specifically to the period of a clock signal, and can hence be easily and accurately tuned. The precise implementation of dynamic equations is enabled this way. Also, systems based on capacitive-emulated resistors are more linear and more compact than other technological alternatives based on purely resistive v-i conversion.

Previous paragraphs describe just one example of many cases where the time variable is employed in smart sensory systems. For instance, time-coding, i.e. the representation of the information through time-related events, is today used to address challenges emerging due to the reduction of the dynamic range

in deep-submicron micro-technologies. Also, time-coding is extensively employed by natural, information-processing systems; and these systems have evolved for some 4billion years to develop high-speed and energy-efficient sensory processing abilities. Furthermore, unveiling the intricate secrets of physics calls for systems capable of resolving events happening in the range of few psecs.

This lecture overviews some basic concepts, methods, and applications related to the generation, control and utilization of time in micro- electronic systems. Whenever possible and convenient, examples corresponding to accomplishments made by the research group of the lecturer will be used for illustration purposes.

Short CV: Ángel Rodríguez-Vázquez (IEEE Fellow, 1999) received the Ph.D. degree in Physics-Electronics (Universidad de Sevilla, 1982) with several awards, including the IEEE Rogelio Segovia Torres Award (1981). After stays at the University of California-Berkeley and Texas A&M University, he became a Full Professor of Electronics at the University of Sevilla in 1995.

He co-founded the Instituto de Microelectrónica de Sevilla, a joint undertaken of Consejo Superior de Investigaciones Científicas (CSIC) and Universidad de Sevilla, and started a Research Department on Analog and Mixed-Signal Circuits for Sensors and Communications.

He has always been looking for a balance between long-term research and industrial innovation. In 2001, he was the main promotor of ANAFOCUS Ltd. and served it as CEO until June 2009, when the company reached maturity as a worldwide provider of smart CMOS imagers. The company was acquired by E2V in 2014 and is currently part of Teledyne Technologies. He also participated in the foundation of the Hungarian start-up ANALOGIC Ltd. Starting in 2019, he is a part of the team of promotors on a new start-up: PHOTONVIS. He has eleven patents filed; ANAFOCUS and PHOTONVIS started based on patents co-authored by him on vision chip architectures and SPAD sensors, respectively.

His research embraces smart imagers, vision chips, and biomedical circuits, always always emphasizing system integration. His Department designed several high-performance mixed-signal ICs in the framework of Spanish, European, and USA R&D programs. These included three generations of vision chips, analog front-ends for XDSL MoDems, ADCs for wireless communications, ADCs for automotive sensors, chaotic signals generators, complete MoDems for power-line communications, etc. Most of these chips were state-of-the-art in their respective fields. Some of them entered massive production. He also produced teaching materials on data converters that were delivered to companies and got the Quality Label of EuroPractice.

His publications have some 9,900 citations and several awards: the IEEE Guillemin-Cauer Best Paper Award, two Wiley's IJCTA Best Paper Awards, two IEEE ECCTD Best Paper Awards, one IEEE-ISCAS Best Paper Award, one SPIE-IST Electronic Imaging Best Paper Award, the IEEE ISCAS Best Demo-Paper Award, and the IEEE ICECS Best Demo-Paper Award. He has an h-index of 49 and an i10-index of 192 (Google Scholar).

He got the 2019 Mac Van Valkenburg award of IEEE-CASS and was elected member of the Academia Europaea in 2019. He has served as Editor for IEEE and non-IEEE journals and is on the committee of several international journals and conferences. He chaired several international IEEE (NDES 1996, CNNA 1996, ECCTD 2007, ESSCIRC 2010, ICECS 2013) and SPIE conferences. He served as VP Region 8 of IEEE CASS (2009-2012) and as Chair of the IEEE CASS Fellow Evaluation Committee (2010, 2012, 2013, 2014, and 2015). He is serving as General Co-Chair of IEEE ISCAS 2020.

Morning Session

Date and time: Thursday 25 June, 11:00
Venue: Virtual Room in University of Seville's online platform `ev.us.es`

Students' presentations

11:00-11:20.- Norberto Pérez Prieto, **"Low-Power low-noise neural recording analog front-ends"**

Abstract: In recent years, the development of implantable biomedical devices has become one of the most explored fields of microelectronics. Pacemakers, cochlear implants or artificial retinas are just some examples of how this evolution of microelectronics is changing people's lives. Within neuroengineering, closed-loop neural implant devices, which simultaneously record and stimulate some region of the brain, are employed to treat neural disorders such as Parkinson's, Alhzeimer's or epilepsy. In this work, we present two analog front-ends which minimize noise and power consumption to be suitable for the acquisition and processing of neural signals, specially for ECoG recording.

11:20-11:40.- Cristina Martínez Gómez, **"A Ring Oscillator TRNG based on Jitter Accumulation with Capability of Auto-Calibration"**

Abstract: A mathematical model is presented that describes how deterministic and Gaussian jitter of an oscillating signal accumulated during a time interval are related to the bits of the binary-coded count value of the oscillations. The model is employed to propose a robust TRNG that has a simple interface (an initialization signal as input and the random bits as output) and that features auto-calibration to certify high entropy of the raw bits provided as well as to work at the highest throughput allowed by the available local Gaussian noise. The mathematical analysis is confirmed with experimental results of ring oscillator (RO) TRNGs.

11:40-12:00.- Valentín Gutiérrez Gil, **"The importance of determining sensitivity to Single-Events on on-board integrated circuits"**

Abstract: Single Event Transients have become a serious issue in safety-critical applications of Analog and Mixed-Signal (AMS) circuits. Therefore, an evaluation must be carried out in order to diagnose the critical nodes but also to get an idea of the global sensitivity of the circuit, as a proxy to its experimental cross-section. In this presentation we will try to put this phenomenon into context and focus on what we are contributing with our work.

12:00-12:20.- Juan Alfonso Serrano Viseas, **"An Empirical-Mathematical Approach for Calibration and Fitting Cell-Electrode Electrical Models in Bioimpedance Tests"**

Abstract: This work proposes a new yet efficient method allowing a significant improvement in the on-line analysis of biological cell growing and evolution. The procedure is based on an empirical-mathematical approach for calibration and fitting of any cell-electrode electrical model. It can be extrapolated for any type of cellular line used in electrical cell-substrate impedance spectroscopy (ECIS) tests. Parameters of the bioimpedance model vary for each cell line, which makes obtaining results difficult and to some extent-renders them inaccurate. We propose a fitting method based on the cell line initial characterization (oscillation-based test, OBT, approach is employed to perform our calibration technique), and carry out subsequent experiments with the same line to approach the cell density.

12:20-12:40.- José Luis Medrán del Río, **"Introduction to balanced microwave devices and first results"**

Abstract: In the last decade, the use of differential signals has been imposed on its single-ended counterpart since they offer a series of advantages that make them most desirable for high speed communications and analog microwave circuits. Different type of devices can be found in their differential version in the literature, such as power dividers, combiners, passive equalizers, diplexers or balanced filters, the latter two being the main focus of this thesis. In this presentation, which will serve as introduction to balanced microwave devices, the differences between differential and single-ended signals will be explained and several designs of filters and diplexers that have been researched will be presented.

12:40-13:00.- Mojtaba Parsakordasiabi, **"A Review of Challenges and Techniques in High-Resolution FPGA-based TDCs"**

Abstract: Applications requiring high time precision cannot rely on counting clock pulses. Time-to-digital converters are needed. They are able to provide high resolution, range and linearity with low resources usage. Several techniques have been introduced to implement TDCs on a FPGA. FPGA-based TDCs have the advantages of higher flexibility, shorter development time, and lower implementation cost than ASIC-based TDCs. In this presentation, we will review the main techniques for FPGA-implementation of TDCs, their relevant parameters and performance characteristics, and the main implementation trade-offs.

Flash Talks

13:00-13:05 Paula de Navascues Garvin: Atmospheric Plasma Sources: Plasma Diagnosis and Environmental Applications.

13:05-13:10 Jesús José Domínguez-Palacios Durán: Modelling of the interaction between ELMs and fast-ions using MEGA.

13:10-13:15 Delia Velasco Montero: A methodology for prediction of visual inference performance on IoT devices.

13:15-13:20 Victoria Lérida: Optimization of limits detection in Accelerator Mass Spectrometry.

13:20-13:25 Alessio Mancini: The SMall Aspect Ratio (SMART) Tokamak.

13:25-13:30 Diego José Cruz Zabala: Recent intrinsic velocity measurements at ASDEX Upgrade.

13:30-13:35 Charanraj Mohan: Memristor Based Event Driven Neuromorphic Nano-CMOS Processor.

Afternoon Session

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Students' presentations

15:00-15:20.- Alejandro Bertolet Reina, **"Analytical models for microdosimetry to calculate dose from alpha emitters used in targeted alpha radiotherapy"**

Abstract: Targeted alpha radiotherapy (TART) is a modality of treatment cancer consisting of using antibodies labeled with alpha emitters to be attached to antigens present in cancer cells. Thus, tumors are irradiated from inside by alpha particles. Dose delivered to cell nucleus has been shown to correlate with cancer control. However, dosimetry at the sub-cellular level is challenging. Recently, our group has developed models to analytically calculate microdosimetric functions for alpha particles. These models can be used to determine the energy imparted to intracellular targets as long as the spatial distribution of alpha emitters is known or assumed. Here, we present a method to apply those microdosimetric models to the TART field.

15:20-15:40.- Antonio López Angulo, **"Description of SAR ADCs with Digital Redundancy using a Unified Hardware-Based Approach"**

Abstract: This work an analysis and review of digital redundancy techniques in Successive-Approximation-Register (SAR) ADCs for correction of comparator errors during the SAR search algorithm. The use of redundancy provides safety margin for dealing with incomplete settling in the DAC network, improving conversion speed and power, as well as relaxing switch sizes and comparator design. Techniques like binary-scaled, radix-based or arbitrary weighing capacitors with redundant bits are discussed using a unified nomenclature and modeling. The proposed unified description is closely related to the hardware realization eliminating the gap between theoretical and physical implementations, and allowing a clear identification of pros and cons of different approaches. For illustration purpose, several examples are modeled and simulated using the proposed description.

15:40-16:00.- Juan Manuel Franco Patiño, **"Semi-inclusive neutrino-nucleus reactions"**

Abstract: Neutrino-oscillation experiments have been relying on inclusive neutrino-nucleus results to obtain the neutrino energy necessary in those oscillation experiments. Good theoretical models have been developed to explain inclusive neutrino-nucleus experiments, where only the final lepton is detected, but very harsh approximations are needed in order to extract the neutrino energy only from the final lepton variables. Future neutrino experiments will be able to detect the final lepton

in coincidence with another particle, for instance an ejected nucleon, giving the opportunity to improve the reconstruction of the neutrino energy by having more information of the final state. An introduction to neutrino-nucleus reactions will be given in this presentation and results for inclusive and semi-inclusive processes will be presented showing the importance of the nuclear structure in the latter.

16:00-16:20.- Adrián García Osuna, **"Characterization of detectors using a nuclear microbeam"**

Abstract: In this presentation, I will explain the nature of my research project, as well as reveal some of the preliminary results obtained so far.

My line of research belongs to the analysis and characterization of novel detectors. For this purpose, we use the particle accelerator and the nuclear microbeam facilities located at Centro Nacional de Aceleradores (CNA).

We use a technique that allows us to irradiate samples with micrometric ion beams. Afterwards, we analyse the experimental results obtained and compare them with theoretical models to obtain some of the device's information.

16:20-16:40.- Salvatore Simone Perrotta, **"Reaction dynamics in clustered nuclear systems"**

Abstract: Coulomb repulsion dominates the dynamics of nuclear reactions between charged particles at very low collision energies (< 100keV). In fixed-target experiments, their cross-section is enhanced, because atomic electrons screen nuclear charges. However, purely atomic processes are insufficient to explain the prominent enhancement measured for several reactions between light nuclei. Some cross-sections required in astrophysical models may thus differ sensibly from currently adopted values.

We approach this issue, called "electron screening problem", from a purely quantum perspective, investigating how the structure in which nucleons arrange themselves within their nuclei (especially when gathering into clusters) may contribute to produce the experimental observations.

16:40-17:00.- Pedro Martín Holgado, **"Combined study of irradiation and temperature on electronic devices: a review of the main achieved tasks and next steps"**

Abstract: In this work, we have a look at the main achieved goals of our research at CNA (irradiation unit), which consist in extending the traditional irradiation test conditions. This new capability of combining temperature and radiation for the electronic characterization activities is especially interesting in the frame of space applications and harsh environments.

We show the key results from radiation tests carried out at room temperature, the design and recent commissioning of the new irradiation chamber, and some outcomes from the first tests already performed at high temperature.