



## Design of Analog-to-Digital Converters with Embedded Mixing for Ultra-Low-Power Radio Receivers

Modern day battery-powered handheld devices are expected to support a wide variety of radio technologies. At the same time, high data rates with reduced latency must be guaranteed, while keeping in mind production costs. These specifications become even more challenging with the advent of 5G, scheduled to have 1.9 billion subscribers by the end of 2024. In the field of radio receivers, down-conversion methods usually rely on one (or more) explicit mixing stage(s) before the analog-to-digital converter (ADC). These stages not only contribute to the overall power consumption but also have an impact on area and can compromise the receiver's performance in terms of noise and linearity. On the other hand, most ADCs require

some sort of reference signal in order to properly digitize an analog input signal. The implementation of this reference signal usually relies on bandgap circuits and reference buffers to generate a constant, stable, dc signal. Disregarding this conventional approach, the PhD research presented at <http://hdl.handle.net/10362/91170> aims to explore the viability behind the usage of a variable reference signal, represented by equation  $V_{Ref}(t) = \alpha + \beta \cdot \cos(2\pi ft + \varphi)$ .

Moreover, it demonstrates that not only can an input signal be properly digitized, but also shifted up and down in frequency, effectively embedding the mixing operation in an ADC. As a result, ADCs in receiver chains can perform double duty as both a quantizer and a mixing stage. In other words, this approach indicates that it is possible to design a receiver chain that forgoes explicit mixing stages, thereby leading to potential benefits, not only in terms of area and power dissipation, but also at the linearity and noise level. Being a significant shift in what relates to conventional design of an ADC and the first of its kind (to the best of the author's knowledge) the viability of the proposed technique as well as the multiple considerations associated with it that a designer must take into account are analysed and some possible solutions are presented. The lesser known charge-sharing (CS) topology, within the successive approximation register (SAR) ADCs, is used for a practical implementation, due to its feature of "pre-charging" the reference signal prior to the conversion. This ensures that during each conversion cycle, the reference is kept constant and the same for each evaluated bit. Regarding the variable reference generation, a phase-locked loop (PLL) is used, hence presenting an integrated solution without the need for dedicated bandgaps and reference buffers. The PLL is flexible enough to generate output frequencies up to 500 MHz. Simulation results from an 8-bit CS-SAR ADC designed in a 0.13  $\mu\text{m}$  CMOS technology validate the proposed technique, with an effective linearity of 7.6 bits and a sampling rate of 50 MS/s burning around 900  $\mu\text{W}$ , suited for moderate resolution and speed communication standards. The proposed technique enables the design of a receiver front-end simply comprised of an LNA-ADC set.



Nuno Pereira

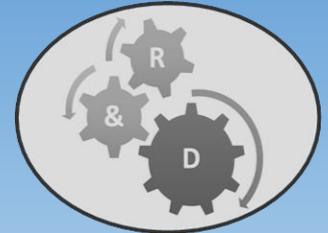
## Editorial

The year of 2019 was very important to reinforce the strategic importance of CTS. Several international and national projects are being coordinated by CTS members and some of them have been presented at the "11th European Innovation Summit", which took place at the European Parliament in Brussels. At national level it is worth to mention the role played by two CTS-lead projects on the national program "Rural Fires: Better Management Based on Scientific Evidence". Several awards have been granted to CTS members and several international conferences have been, and are going to be, organized by CTS.

The CTS newsletter editorial board wishes to all CTS members a fruitful 2020.

João Martins

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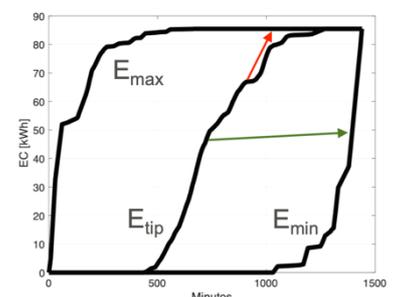
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## On the use of flexibility (João Martins and Rui Lopes)

The Energy Flexibility of a building can be regarded as the ability to manage its energy demand and generation according to local climate conditions, user needs and grid requirements. Flexibility can be seen in an implicit way (where it can be obtained by varying tariffs or using penalty conditions) or in an explicit way (using specific services such as energy storage or load deviations). Considering not just a single dwelling but an aggregate set of dwellings (for example a building, a neighbourhood or a community) brings added benefits to the use of energy flexibility, in this case aggregate flexibility. For energy communities please refer to the newly approved law (Decreto-Lei n.o 162/2019) where they are legislated. In the case of electrical appliances, flexibility can be regarded as the possibility of postpone the energy consumption as much as possible, or the possibility of all the appliances consume energy as early as possible. The typical power consumption generates an accumulated energy consumption pattern denoted by  $E_{tip}$ . Both previous scenarios will generate accumulated energy consumption patterns denoted, respectively, by  $E_{max}$  and  $E_{min}$ . Both of these patterns are calculated based on the flexibility of every appliance, home or community. At any moment, given the availability of appliances at that particular moment, a power consumption increase can be realized up to the maximum available power (evolving from  $E_{tip}$  to  $E_{max}$  – red arrow). The dual situation can be also considered. At any time a power decrease can be achieved (being zero, in the limit, for the controllable appliances – green arrow) evolving from  $E_{tip}$  to  $E_{min}$ . Given the accumulated energy consumption patterns, it is straightforward to choose the use of flexibility (and how much energy is involved) in order to postpone or anticipate that energy consumption, taking into consideration that the overall consumption will be the same by the end of the day.



## Recent PhD thesis in Electrical and Computer Engineering

The year of 2019 was very fruitful on accomplishing PhD thesis of our members. Below is the list of the recent achievements. CTS acknowledges their research efforts contributing to the quality enhancement of the centre.

a) Elena Nikolaevna Baikova (15 Mar 2019)

Transferência de Energia sem Contacto:  
Estudo das Emissões do Campo Elétrico  
Supervisors: Stanimir Valtchev and Vitor Pires

b) Thais Andrea Baldissera (2 Oct 2019)

Evolutionary Service Composition and  
Personalization Ecosystem for Elderly Care  
Supervisor: Luis M. Camarinha-Matos

c) Luis Miguel do Rosário Irio (3 Dec 2019)

Interference Characterization in Multiple  
Access Wireless Networks  
Supervisor: Rodolfo Alexandre Duarte Oliveira

d) Ricardo Alexandre Fernandes da Silva Peres (5 Dec 2019)

An Industrial Data Analysis and Supervision Framework for Predictive Manufacturing  
Systems  
Supervisors: José Barata and Paulo Leitão

e) Nuno Rúben Ferreira Pereira (17 Dec 2019)

Design of analog-to-digital converters with embedded mixing for ultra-low-power radio receivers  
Supervisor: João Goes



- **UAVs for prescribed fires and rekindle detection operations**
- **foRESTER - Sensor network combined with fire spread modelling integrated into a decision support system for forest firefighting**

The Portuguese Foundation for Science and Technology (FCT), together with ForestWISE - Collaborative Laboratory for Integrated Forest and Fire Management and the Agency for Integrated Rural Fire Management (AGIF), organized a session on “Rural Fires: Better Management Based on Scientific Evidence” (program ) on November 27th, in the Auditorium of the Portuguese Institute of Sea and Atmosphere (IPMA), in Algés.

At this event were presented and discussed the projects supported by the FCT within the scope of the Scientific Research and Technological Development Project Competition in the context of

Forest Fire Prevention and Fight. Two CTS researchers (Luis Bica Oliveira and José Barata) participated with presentations for the conception and implementation of forms of governance and risk management of rural fires based on scientific knowledge, and in the prevention and control of rural fires (presenting two CTS projects). The main goals of this event were the establishment of scientific cooperation networks, the promotion of multidisciplinary knowledge and the identification of knowledge gaps.



## ETHNA - Bringing ethics into practice to manage Responsible Research and Innovation

Partners from all over the EU have joined forces to develop a framework that will help European research institutions to implement ethics in their research. In the kick-off meeting for the ETHNA System project, the ten partners from eight countries met in Castellón to outline the first steps. ETHNA System aims to establish a management system of the Responsible Research and Innovation (RRI) within 6 European Higher Education, Funding and Research Centres: two universities, two research funding centers and two technology parks in Spain, Norway, Estonia, Bulgaria, Austria and Portugal. To do that, the consortium will implement Living Labs, an approach uniquely suited to identify approaches to successfully put ETHNA System into action. "This project will allow us to work so that what is good can be real," said project coordinator Elsa González from the Universidad Jaume I. "Our goal is to bring ethics from theory into practice." The rector of the Universitat Jaume I, Eva Alcón, welcomed the partners in Castellón. "There are three years of hard work ahead of you, but also the challenge of making visible the importance of Human and Social Sciences in research and the transfer of knowledge to society," she said. The funding for the project comes from the EU's Horizon 2020 call "Grounding RRI practices in research and innovation funding and performing organisations". CTS – UNINOVA will apply ETHNA results to its research ecosystem for improvement of current processes, mechanisms and structures for RRI, namely:



Attendants of the ETHNA kick-off meeting, with the participation of the director of CTS

• RRI, including research ethics, on all activities of research and publication.

• RRI, including research ethics, for advanced training, namely PhD program, and organization and evaluation of scientific and dissemination events.

• RRI, including research ethics, on all activities of technology transfer and collaboration with industry and other societal actors.

## IMPACTOUR Project Starts

- The IMPACTOUR project started on 1st January 2020.
- The project has received € 2.971.250 funding from the European Commission to "create an innovative and easy-to-use methodology and tool to measure and assess the impact of Cultural Tourism".
- 12 project partners, from nine EU Member States work on the project, funded by the EU Horizon 2020 Research and Innovation Programme (from January 2020 to December 2022).
- The Kick-off-Meeting took place in Lisbon last January 28-29th.



Kick-off meeting of the IMPACTOUR project at FCT/UNL, with all 12 project partners

IMPACTOUR will develop a sustainable ecosystem by engaging Cultural Tourism stakeholders and following a participatory approach. IMPACTOUR tools and methods will lead to reinforcing the commitment to enhance Europe as a cultural tourism destination, increasing local citizens' sense of belonging, promoting minority cultures, strengthening identities and sense of belonging. IMPACTOUR Methodology will be completed and tested with data coming from 15 Data Information Pilots and the IMPACTOUR tool will be validated in 5 Validation Pilots, with distinct characteristics spread around Europe.

## CTS projects presented at the European Parliament

On February 5<sup>th</sup> 2020, Virgílio Cruz Machado (Director of FCT NOVA) and Ricardo Jardim Gonçalves (CTS member), presented three European projects (38M€ budget) led by CTS at the "11th European Innovation Summit", which took place at the European Parliament in Brussels.

The projects presented were Smart4Health, ZDMP and DIH4CPS. Smart4Health intends to serve in interoperability, namely in the European electronic health registration service, responding to the citizens' needs to manage their own health, enhancing personalized solutions in this field, being the European response to the strategy of digital transformation and support to social innovation. The ZDMP (Zero Defects Manufacturing Platform) project will develop a digital platform for the manufacture of non-defective products, allowing current factories to achieve manufacturing excellence. The DIH4CPS project (DIHs for Embedding Interoperability in Cyber-Physical Systems of European SMEs) is an initiative that aims to encourage and catapult European digital innovation HUBs, with a special focus on the connection between research and the production of value in SMEs at European level.



## NEWS

## Visit to China

Prof. Luis Camarinha-Matos, director of CTS, was invited to visit the Beijing Jiaotong University, Business and Management School, in the period 8-14 Dec 2019. The program of the visit included:

- Discussion and giving advice on current PhD research programs on Collaborative Networks.
- Discussion of collaboration possibilities between the two research institutions in the area of Collaborative Networks and Digital Transformation.
- Giving a 2 h lecture to the PhD students of the Information Systems Research program on the topic of "Collaborative Networks and Industry 4.0".
- Giving a 2 h lecture to the PhD students of the Information Systems Research program on the topic of "Towards a PhD: Research method, Thesis preparation, Publications".
- Giving a 3 h seminar on "Collaborative Networks – Contributions and Perspectives" to researchers and PhD students of the Business and Management School. This seminar included an overview of the CTS activities.
- Giving a 3 h lecture to the MBA students of the Information Systems program on the topic of "Collaborative Networks –



Prof. Camarinha-Matos with the research group of Prof. Juanqiong Gou.

## Visit of Beatriz Andres

Beatriz Andres, Professor at the Polytechnic University of Valencia, Campus de Alcoy, Spain, visited the CoDIS research group of CTS in the period 17-21 Nov 2019.

During her visit, Doctor Andres had the opportunity to discuss research issues with researchers and PhD students of the Collaborative Networks group.

Furthermore, she also gave two lectures to the MSc students on Electrical and Computer Engineering of the FCT-NOVA:

- “e-aPlan for the Collaborative Aggregate Planning” (2 h) for the students of the Intelligent Supervision course.
- “IMPLEXA software for the Supply Chain Management” (2 h) for the students of the Distributed Manufacturing Systems course.

Further news at: <https://muiol.blogs.upv.es/2019/12/12/implexa-viaja-a-la-universidade-nova-de-lisboa/>



Beatriz Andres at the Distributed Manufacturing Systems class

## AWARDS

### Technological Innovation Award

1st Place in Technological Innovation Award Eng. Jaime Filipe, delivered in the city of Santarém on the International Day of People with Disabilities, 2019-12-03, promoted by the Portuguese National Institute for Rehabilitation (www.inr.pt).

#### **“Human Interface System for Computer Access”.**

Interface system designed to allow computer access to people with special needs by replacing the mouse, keyboard and gamepad. The field of application of the developed interface system covers the assistance of various sensory and motor limitations, where a human user has little or no control of his hands, being unable to use a common Human-Computer Interface.

The small device can be placed in different parts of the human body. It incorporates an electronic controller that allows to assist and improve the performance and reduce the effort of the user with special needs in the access to the computer.

The award was given to Prof. Rui Azevedo Antunes, as part of his PhD work carried out at the Department of Electrical and Computer Engineering (DEEC) of the Faculty of Science and Technology (FCT) of the NOVA University of Lisbon (UNL), in partnership with the UNINOVA - Center for Technologies and Systems (CTS), under the supervision of Prof. Luís Brito Palma and the co-supervision of Prof. Hermínio Duarte-Ramos. Rui Azevedo Antunes is Adjunct Professor in the Department of Electrotechnical Engineering (DEE) at the Setúbal Higher School of Technology (ESTSetúbal) of the Setúbal Polytechnic Institute (IPS), a researcher at CTS-UNINOVA and at the Interdisciplinary Center for Applied Health Research (CIAS-IPS). Luís Brito Palma is Professor at DEEC-FCT-UNL and a researcher at CTS-UNINOVA. Hermínio Duarte-Ramos is Emeritus Professor at DEEC-FCT-UNL.



### Best Paper Award

A Best paper award was given to Javaneh Ramezani, PhD student of CTS, in the conference ITQM 2019 – 7th International Conference on Information Technology and Quantitative Management, 3-6 Nov 2019, Granada, Spain

Paper: “A collaborative approach to resilient and antifragile business ecosystems” (Javaneh Ramezani, Luis M. Camarinha-Matos)



### “Partner” award by APCAS - Associação de Paralisia Cerebral de Almada Seixal

In recognition of the collaboration with APCAS - Associação de Paralisia Cerebral de Almada Seixal (Association of Cerebral Palsy of Almada Seixal), FCT-NOVA was awarded with the “Partner” award by the Board of APCAS. The award was delivered on December 7, 2019 during the APCAS Gala, held at Amora Secondary School. This collaboration started in January 2013, has been involving two CTS members (Luis Gomes, Anikó Costa) and a group of three or four undergrad students every year during five weeks, and has allowed the adaptation of common toys, allowing their use by children with various motor constraints. The website <http://sites.uninova.pt/brinca/> is a repository of the adaptations of toys made during the years.

## Habilitation of two CTS' members

- João Martins, member of CTS, successfully passed his Habilitation exam on Electrical Engineering at the NOVA University of Lisbon (NOVA FCT), 19-20 Dec 2019
- Antonio Abreu, member of CTS, successfully passed his Habilitation exam on Industrial Engineering at the University of Aveiro, 26-27 Feb 2020



## EVENTS

## Past events (2019)

### The 45th Annual Conference of the IEEE Industrial Electronics Society



The 45th Annual Conference of the IEEE Industrial Electronics Society (IECON'2019) was held at Lisbon Congress Center, in Lisbon, Portugal, from October 14 to 17, 2019 and attracted almost 1300 participants. More than 1600 manuscripts (coming from 69 countries, considering the country of contact author) were received, submitted to 15 technical tracks and 80 special sessions. The number of papers included in the program was 1143, organized in 112 oral-only technical sessions and 35 oral-interactive technical sessions. Seven tutorials and three keynotes were offered. Opening session had the presence of IEEE Industrial Electronics Society President, Prof. Xinghuo Yu, as well as Prof. Toshio Fukuda, IEEE Present-Elect and Prof. Manuel Castro, IEEE Division VI Director. Several CTS members were involved at different level of the organizing committee, from General Co-Chair to Local Organizing Committee, as well as at the Technical Program Committee, including special sessions co-chairs, track co-chairs and special session organizers.

Several co-located events were successful organized, namely Women in IES Forum in Europe, Industry Forum, Young Professional and Students Forum, and INTEROP – Standards Interoperability and Plugfest. CTS members contributed to their organization and coordination.

Complementing the technical activities, participants had the possibility to explore Lisbon, announced the World's Leading City Destination and the World's Leading City Break Destination for the World Travel Awards 2018, as well as to benefit from social events occurring at the Congress Center, namely the reception, the gala dinner, and a performance from the Fado singer António Pinto Basto.

## Upcoming events (2020)

### DoCEIS 2020

<http://doceis.dee.fct.unl.pt>



### YEF-ECE 2020

<http://sites.uninova.pt/yef-ece>



### POWERENG2020

<http://cpe-powereng2020.uninova.pt/index.htm>



### PRO-VE 2020

[www.pro-ve.org](http://www.pro-ve.org)

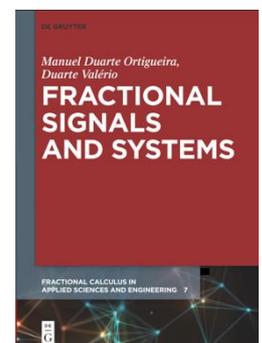


## BOOKS

## Fractional Signals and Systems

*Manuel D. Ortigueira and Duarte Valério*

New book of a CTS member, Prof. Manuel Duarte Ortigueira, co-authored by Duarte Valério, being published in Feb 2020. "This book covers the theory of signals and systems, addressing in parallel both the cases of integer order systems and fractional order systems. The theoretical results of fractional derivatives are thus illustrated via their applications. Both time and frequency analysis are presented. Some advanced topics are included like derivatives of stochastic processes. This book is an essential reference for researchers in mathematics, physics, and engineering."



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