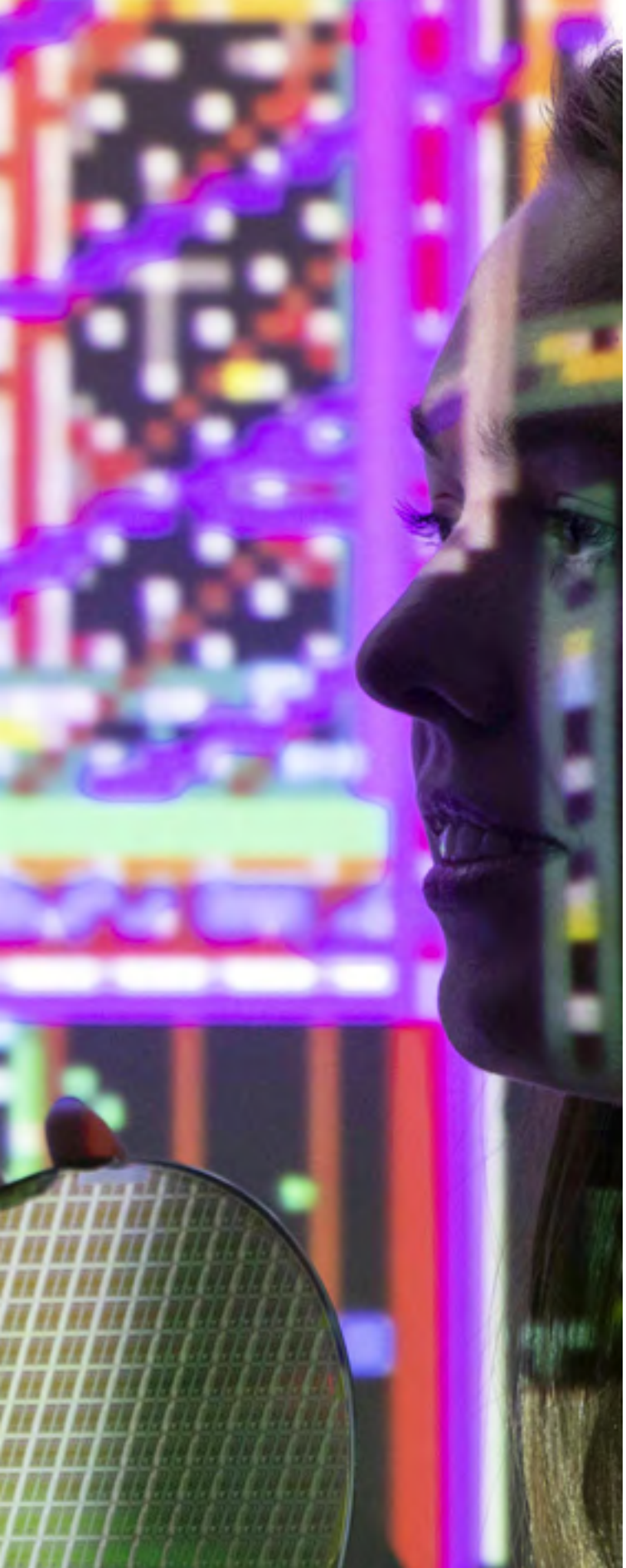
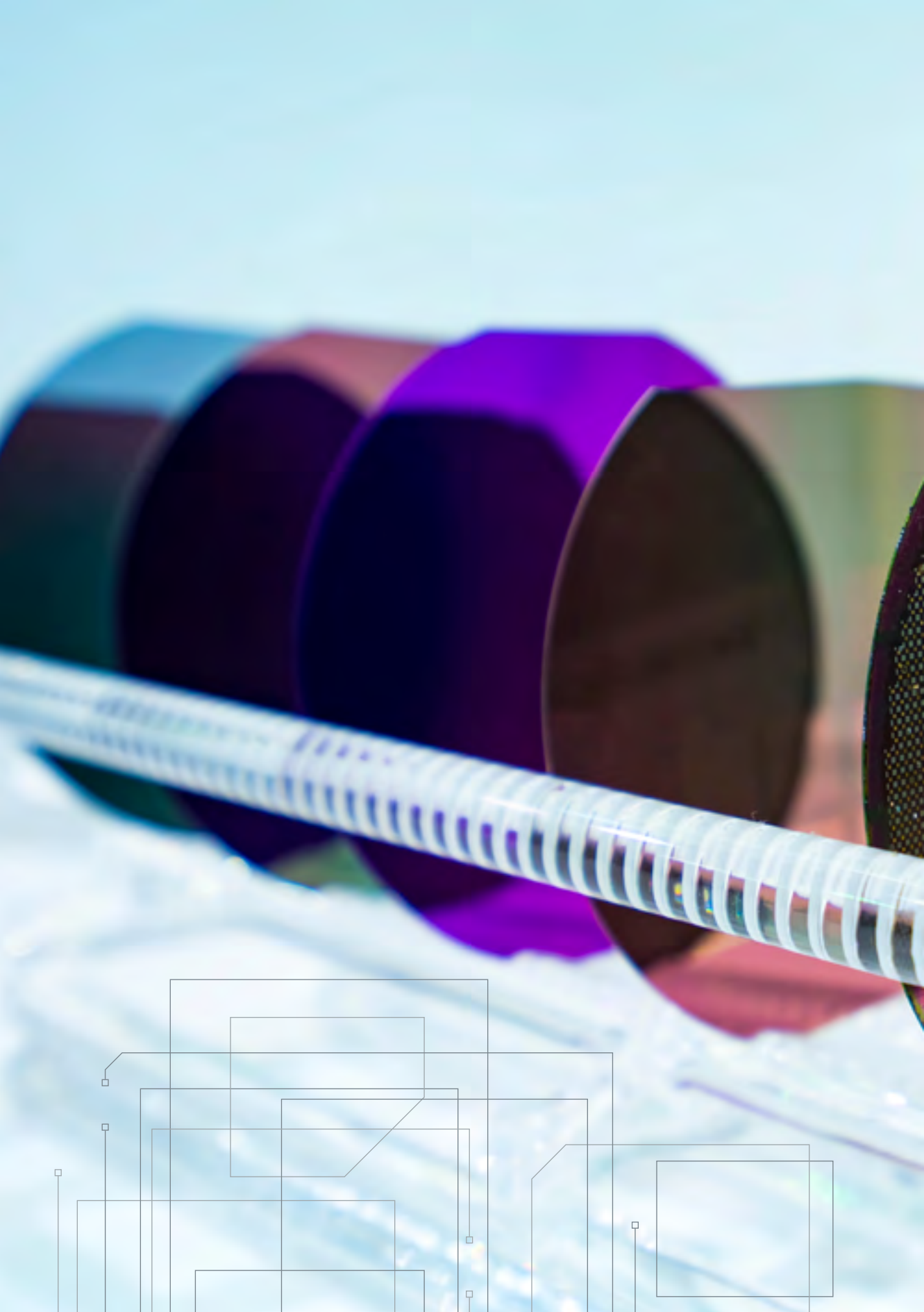


ANNUAL REPORT 2018

MCCI
Microelectronic Circuits Centre Ireland

TECHNOLOGY CENTRE
SUPPORTED BY ENTERPRISE IRELAND



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CHAIRMAN AND EXECUTIVE DIRECTOR'S MESSAGE

CHAIRMAN'S MESSAGE

MCCI is operating in an important research area for the Irish economy in delivering world class microelectronics circuits research. In a global industry which, despite current trade tensions, continues to see strong growth driven by changing technology cycles and market drivers, it has become imperative to have a strong microelectronics sector, in order for the country to participate in that growth.

The vision of the centre is to be 'the number one microelectronic circuits research centre globally, for industrial and academic collaboration by 2025'. MCCI is expected to grow to over €8.1m per annum by 2020.

In Ireland there is an established and sophisticated research-intensive microelectronics sector. With approximately 8000 directly employed and €9B in annual direct export revenue, microelectronics is key to supporting the larger €50B Irish ICT export sector.

A feature of the semiconductor sector globally over the past 5 years had been the M&A activity, and Ireland was no different with many if not most of our indigenous companies acquired by larger FDI companies. We have yet to see evidence of this leading to new indigenous firms restarting post these acquisitions however, and so the sector is still not where it needs to be in terms of scale to continually regenerate and reinvent itself through different business cycles.

MCCI plays a key role through the generation of talent, in particular post-graduate, future leaders in the sector. The scaling of the centre is a key part to achieve the critical mass required to reshape a sector that is today dominated by FDI companies, to one that is more balanced with a naturally occurring cycle of spinout, start up and acquisition in a national context

MCCI is producing trained staff at a rate of ~10 per annum and ~2 commercial licences per annum. It is beginning to see the quality of research increasing to a global standard and has strong research roadmaps driven actively by industry. MCCI research has also had a positive influence on the number and quality of post-graduates entering the workforce. These are the future leaders that will bring the sector to the next level in terms of employment and contribution to GDP.

Research outcomes are driven by key application and system level requirements, which are informed by the centre's industry partners, and co-located research groups in Photonics, Materials science, electrochemistry and Medical Devices, at Tyndall National Institute and our partner universities.

The ability to leverage knowledge embedded in these "Research hubs" in Tyndall is an important differentiator for MCCI and will continue to be as the centre will scale over the coming years in line with the needs of industry.

MCCI has become an integral part of the research eco system in Ireland & increasingly Europe collaborating with, and enabling, several thematic centres (for example SFI CONNECT & IPIC) and as a collaborator on several H2020 programs, bringing the microelectronics circuits expertise to their respective programs. They will continue to emphasise collaboration across the ecosystem, and in particular European opportunities, positioning the Centre as a key enabler of technology. There is a huge opportunity for MCCI to be a world leading industry-led analogue and mixed-signal research centre by 2025. Scaling the pipeline of talent that the centre produces will position Ireland as a leading country for foreign direct investment, and new microelectronics start-ups with the opportunity to create thousands of jobs.

Donal Sullivan
Chairman

EXECUTIVE DIRECTOR'S MESSAGE

We are an industry-led research centre that focuses on solid state circuits research relevant to our industry partners, and I'm delighted to see the continued growth and success of MCCI in this past year. In 2018 we completed a successful centre review, led by an international panel of experts, which highlighted the impact we have made to the microelectronics sector since 2015. These include 458 new jobs created and over €27m additional revenue generated by our member companies as a result of research collaboration with the centre.

Furthermore, the companies most engaged in research with the centre forecast this revenue impact to grow to €432.4m by 2023. The benefits to member companies of engaging with the centre are clear, but these numbers represent a forecasted economic value add of almost €150m directly to the economy, or a 20:1 return on investment by the exchequer. Significant effort was put into the preparation of our business plan for phase 3 funding from Enterprise Ireland & IDA, and we are awaiting the outcome with confidence.

The key strengths and differentiators which enable us to continue to grow with the demands of industry were remarked upon by the review panel, including very positive feedback from stakeholders in terms of engagement and alignment of the research programme. The impact this research alignment has on our members is evidenced by their continued ability to secure investment, including corporate R&D investment for the Irish operations, securing and growing research jobs here. Personally, I am proud of the high level and diversity of industry engagement, and alignment that MCCI has with our member companies.

We will continue to apply our collaboration model, as we begin to address new application areas which are big research opportunities for MCCI in the Medtech, Smart Agriculture and Food industries. MCCI is well established as a single point of contact for access to high calibre academic research in the field of microelectronics in Ireland. Our research team are central to our success as they work on ground breaking innovations that push the boundaries.

The quality of MCCI staff was widely recognised in 2018 when Dr. Ivan O' Connell was awarded a Science Foundation Ireland (SFI) Award for Industry Partnership. The SFI Industry Partnership Award celebrates a collaboration between an SFI-funded academic research group and industry. This past year also saw us further strengthen the core research team

with the appointment Dr. Jeff Walling as Head of Group for RF transceivers to drive this research pillar forward. He joins the centre from the University of Utah where he held an Associate Professorship in the Department of Electrical Engineering, and will continue to hold an Adjunct roll there.

We strive in our work, not just for research excellence, but to inspire and develop future talent for the global semiconductor industry, and in 2018 we had our 50th transfer to industry further adding to the MCCI alumni.

Our vision is to "be the number one Microelectronic circuits research centre globally, for industrial and academic collaboration by 2025", we are well on our way to achieving our vision. I would like to thank the Enterprise Ireland Technology Centres programme for their continuing critical support and valuable partnership.

Finally, I would like to thank our staff and students for their commitment and dedication to excellence and hard work. You continue to drive MCCI's many achievements and have made 2018 another successful year.

Donnacha O'Riordan
Executive Director

ABOUT US

The Microelectronic Circuits Centre Ireland (MCCI) was founded to deliver high impact research for the semiconductor industry. Funded by Enterprise Ireland and the IDA, the role of MCCI is to generate innovative technologies. MCCI acts as a single point of contact for the microelectronics industry in Ireland to access academic research. The centre has an annual research revenue in excess of €8.1million and a team of over 90 researchers and engineers across Tyndall National Institute, UL and UCD, collaborating on more than 50 research projects.

MCCI undertakes collaborative projects in the microelectronics circuit design space with an emphasis on mixed-signal, Analogue and RF circuits. Projects may have algorithm, digital design, IC architecture or system architecture components to them where these can lead to improved performance of mixed-signal circuits.

RESEARCH PILLARS

High Speed Transceivers

Power Management

Precision Circuits

Digital

KEY IMPACTS

€8.1M

Research annual funding to microelectronics circuits

90+

Researchers supported

€27M

Additional revenue generated by member companies since 2015

€150M

Economic value add to the Irish economy

20:1

ROI on state investment in microelectronics research

15

Commercial IP licenses

458

New jobs created since 2015

VALUE PROPOSITION

For Industry

- Foremost we provide a single point of contact for industry, to access academic research across relevant universities.
- With an open innovation, collaborative research model and transparent IP rules we build trust among our academic and industry partners.
- Clean simple process for IP creation and ownership.
- A diverse industry membership gives us access to application knowledge across the value chain that individual members would not have.
- We undertake research and will develop solutions that push state of the art, ensuring global competitiveness for our members, and we are already approaching 70 publications in peer reviewed journals and conferences.

For Academia

- We support research with state of the art infrastructure, EDA tools, methodologies, processes and support.
- We now have a critical mass of experts and thought leaders in our domain.
- We bridge the gap between research and industry and provide a path for fundamental research commercialisation.
- We enable access to a broad representation from industry across multiple application and technology areas.

For the State

- Microelectronics is a key enabling technology, enabling the major ICT trends globally, ensuring Ireland Inc. is competitive, and participates in that growth.
- We have become an essential research partner for industry.
- We are growing the Irish talent pool for microelectronic engineering, which secures R&D jobs through active academic interaction and attracts further FDI investment in the sector.
- We provide insight, expert opinion and a forum for innovation, sharing insight and networking. As a centre funded by state agencies we have influence on national research policy.

OUR VISION

Be the number one Microelectronic circuits research centre globally, for Industrial and Academic collaboration by 2025.

OUR MISSION

Our mission is to deliver high impact research outcomes, and by doing so develop our researchers into independent thinkers and future leaders in Irish companies and in the global semiconductor landscape.

MCCI is the only industry-led microelectronic circuit research centre in Ireland.

We want to be the first choice for microelectronics research that enables future products and applications. We recognise that microelectronics is at the heart of all technology, driving and powering the Irish economy. Our vision emphasises high impact research outcomes, but beyond that the development of our researchers into independent thinkers and future leaders in Irish companies and in the global semiconductor landscape. We value the trusted networks of industry-led collaborative research, and commit to timely execution that benefits not only our industry partners, but which contributes fundamentally to a better, more prosperous society.

Since our foundation it we have become the go-to place for industry to carry out research with academia in the area of microelectronics. Our focus is on microelectronics circuits research servicing the €9B, 8,000-person industry in Ireland . In the context of the national research priority areas, we focus on microelectronics as a platform technology. Microelectronics enables many of the 14 priority areas such as Future Networks, Medical Devices, Connected Health, Diagnostics plus Smart Grids and Smart Cities.

By providing world-leading research in Higher Education Institutions (HEIs), we give a competitive advantage to microelectronics companies located in Ireland leading to the generation of employment and an increase in export revenue. This will include:

1. Increasing the relevance to industry of circuit research carried out in HEIs.
2. Making the IP more accessible to industry.
3. Increasing the quality of circuit research carried out in the HEIs.
4. Increasing the scale of relevant research carried out in the HEIs.

Our application areas

Future networks communications & IOT

Security, AI & Machine learning

Medical devices & diagnostics

Connected health

Smart agriculture

CURRENT MEMBERS

RESEARCHER PROFILES

OUR RESEARCH LEADERS

Dr. Ivan O'Connell

Prof. Bogdan Staszewski

Dr. Jeff Walling

Prof. Anding Zhu

Mr. Seamus O'Driscoll

Dr. Barry Cardiff

Dr. Padraig Cantillon Murphy

Dr. Brendan Mullane

Prof. Peter Kennedy

Dr. Emanuel Popovici

Dr. Ivan O'Connell, Head of Precision Circuits

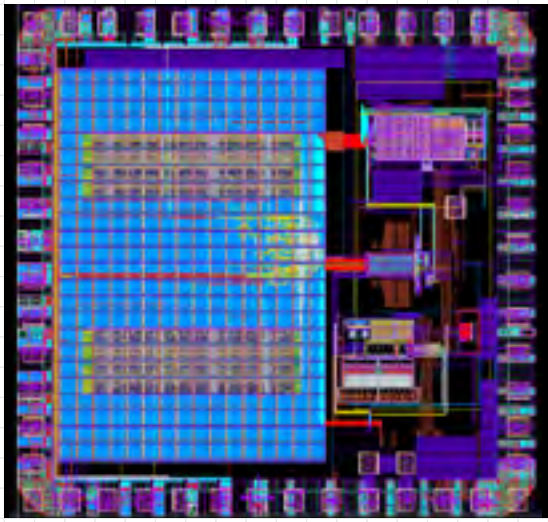
Ivan joined MCCI in 2013 and is the Head of Group of the MCCI core research team. Since joining MCCI he has grown the MCCI core team to 20 researchers, which consists of Masters and PhD students, Postdocs, Research Assistants and Senior Researchers. His primary research interests are in the area of Analogue Mixed Signal Circuits and data converters. He is particularly interested in the application of this research in areas including: Internet of Things, Biomedical, Smart Agri and Energy Harvesting. He is currently a principal investigator in a number of Innovation Partnerships and Commercialisation Funds. He is involved in a number of H2020 projects. In addition, he is an SFI CONNECT Funded Investigator and is actively involved in the newly funded SFI centre VistaMilk. Prior to joining MCCI, Ivan was the Design Manager in ChipSensors, which was subsequently acquired by Silicon Laboratories in 2010. While there, he lead the development of their digital relative humidity and temperature sensor products, from initial concepts, through to initial and interim prototypes, to their subsequent commercialisation, including custom test development. Since joining MCCI, he has secured €6 million in funding, in addition to 8 commercial licenses and transferring 22 trained researchers to industry. Since 2016, he is a member of the Custom Integrated Circuits Conference Technical Programme Committee. In November 2018 Ivan was awarded Science Foundation Ireland (SFI) Award for Industry Partnership.

Dr. Daniel O'Hare, Senior Researcher

Current Research: Senior Researcher (analog / mixed signal) at MCCI, Tyndall National Institute, Cork, where he is design lead/architect investigating high precision embedded ADCs for sensor applications. His current research includes investigating a novel noise shaped SAR architecture and implementing it using TSMC 28nm HPC CMOS technology and low noise, high dynamic range trans-impedance amplifiers for precision current sensing.

Research Topics: Danny's research interests are low noise, low voltage analogue interface circuits and ADCs. These interests are applied in ASICs for sensor applications with current sensing interfaces a strong interest. Based on his previous work in the University of Limerick Continuous- Time ADCs and reference and input Buffers for high performance ADCs are a continuing interest. Danny spent 12 years as a baseband designer for many generations of multi-mode cellular transceiver chips working for M4S NV an Imec spinout and Freescale/Motorola. Low power radios remain an interest.

Education: PhD Electronic Engineering from University of Limerick (2018). Thesis title "Design of Continuous Time Input Pipelined ADCs for advanced CMOS technologies"



Top-level chip layout for 1.5GHz Noise-shaped SAR ADC on TSMC 28nm

Anita Schuler, Senior Digital Design Engineer

Current Research: 1.5GHz Noise-shaped SAR ADC on TSMC 28nm

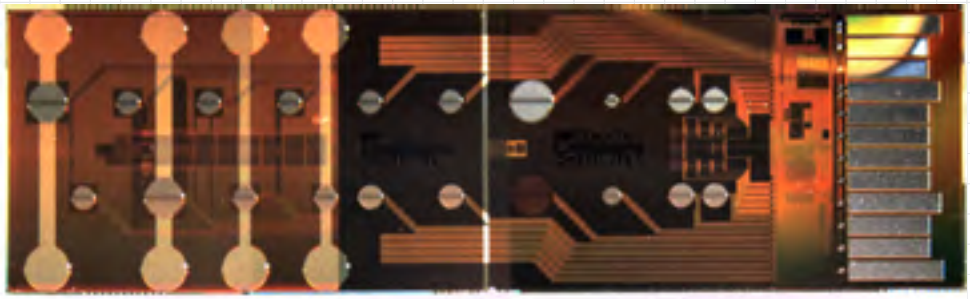
Research Topics: Digital design for ADCs, including specification, design, Verilog RTL Coding, verification, synthesis, place and route and gate-level back-annotated simulations.

Digital PLL on TSMC 28nm

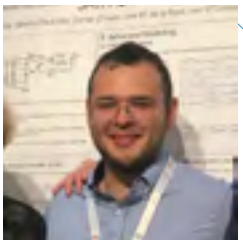
Digital-on-Top auto-routing using Cadence Innovus

Verilog and Digital Design consulting to other groups in Tyndall/UCD

Education: Anita holds a B. Eng (Electronic Engineering), University of Limerick, 1994. First Class Honours.



Top level die photo of a Capacitive to Digital Converter for Magnetic Bead detection in 0.35um CMOS process

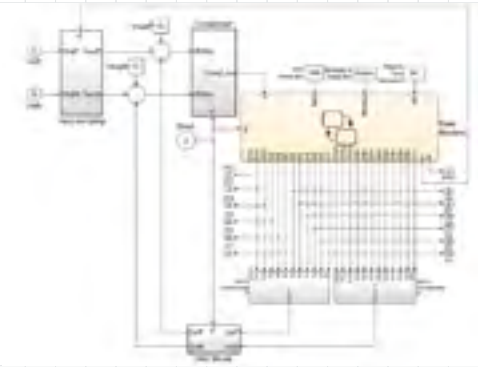


Dr. Gerardo Salgado, Senior Researcher

- Current research: Investigating novel high-resolution Analog-to-Digital Converter (ADC) topologies suitable for nanometer CMOS processes, ≤28nm.
- Improving the capabilities of MCCI's SIMSAR Simulink®-based toolbox.
- Research topics: Behavioral modelling and design of Computer-Aided-Design tools
- SAR ADCs
- Sigma-Delta Modulators (Discrete and Continuous time)
- Digital Signal Processing (Filter design)

Education: Gerardo Salgado received the B.S., M.S and Ph.D. degrees in Electronics Engineering form Institutes ITP and INAOE, Mexico, in 2009, 2011 and 2015, respectively. During his Ph.D. studies, he joined the Microelectronics Institute of Seville (IMSE), Seville, Spain, and Texas A&M University, USA, as a visiting scholar. Since January 2016 he has been working as a postdoc researcher at MCCI.

SIMSAR Toolbox developed at MCCI and available online as a free download at www.mcci.ie



Aidan Murphy, PhD Student

Current Research: As sensing technologies develop, there is an increase in the demand to take measurements at the point of sample. MCCI are collaborating with the Nanotechnology Group in Tyndall to enable point of care electrochemical sensor detection. A variety of voltammetric techniques have been enabled on the data acquisition system. Results have been accepted for publication at the International Instrumentation and Measurement Conference, Houston, 2018 and IEEE Nano, Cork, 2018. The system is now battery powered and wireless connectivity has been enabled via Bluetooth. It can be interfaced to via an android smartphone application. Current work is focused on enabling more electrochemical tests and miniaturising the system.

Research Topics:

- Embedded Systems
- Electrochemistry
- Nanotechnology

Education: Aidan received his BE degree in Electrical and Electronic Engineering from University College Cork in 2016 and is currently pursuing a PhD degree with MCCI, University College Cork

ADuCM350 Evaluation Board with nanowire sensor connected

Subhash Chevella, Senior Design Engineer

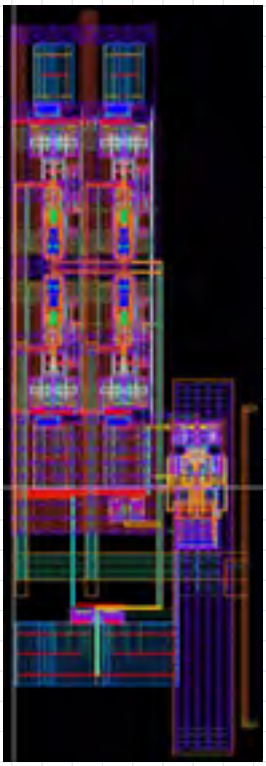
Current Research: Current research involved in investigating High Speed Signal Driver architectures for high precision ADCs and Digitally Assisted techniques to improve performance for Low noise, High Speed Dynamic Amplifier.

Research Topics: Investigating the techniques to improve linearity and noise in Analog Engineering blocks, Calibration mechanisms for Dynamic Amplifiers, Comparators, Analog & Mixed Signal Integrated Circuits and Continuous Time Data Converters, Low Power Differential Amplifiers.

Education: Master Of Technology in Information and Communication Technology at DAIICT, Gandhinagar, India.

During Master's degree research was involved in Analysis of Charge injection, Clock Feedthrough and Capacitor mismatch in Switched Capacitor Circuits, techniques to minimize mismatch.

Bachelors of Technology in Electronics and Communication Engineering at JNTU, Hyderabad, India.



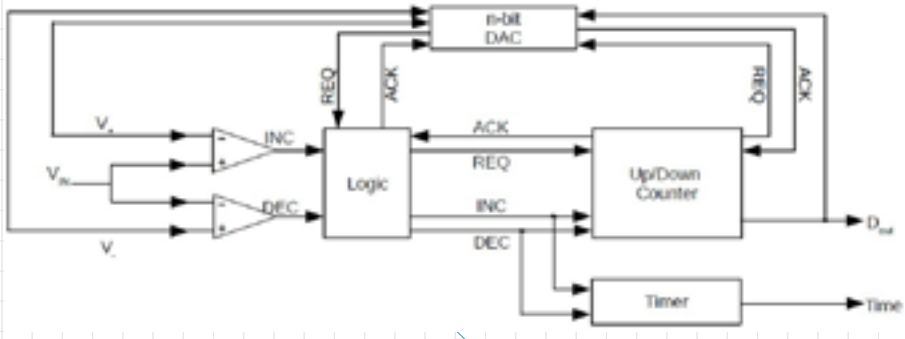
Annamaria Fordymacka, PhD Student

Current Research: The research here is on ultra-low power sensor interface ADC for Internet of Things (IoT). Successive Approximation Register analog-to-digital converter (SAR ADC) is currently a popular architecture for low power applications. However, as with most of the conventional ADCs it samples the input signal periodically, which is not efficient for applications where signals are sparse and their frequency content varies with time. In level-crossing sampling, samples are generated only when the input signal crosses the threshold levels but it can suffer from slope overload. The research focus is to investigate different ADC architectures and to develop a novel circuit design that could allow us to perform sampling more efficiently for high-frequency and high-amplitude inputs while still keeping the ADC at low power.

Research Topics:

- Analog and Mixed-Signal IC Design
- Hybrid Data Converters
- Low Energy Applications
- Sensor Interfaces

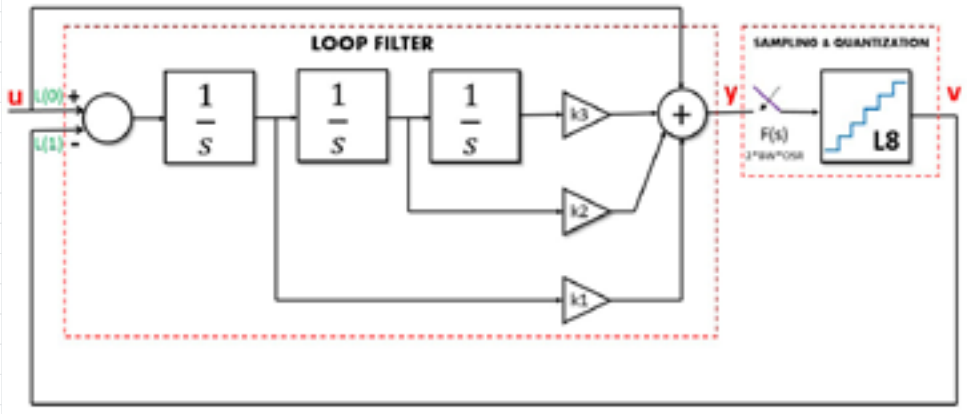
Education: Annamaria graduated from UCC with a Bachelor's Degree in Electrical & Electronic Engineering in 2014. After her graduation, she joined MCCI at Tyndall National Institute where she completed her Master's degree in 2016. She is currently a PhD researcher in MCCI under the supervision of Dr Ivan O'Connell. The primary focus of her research is mixed signal/analogue IC design.



Level Crossing ADC Architecture

Spyros Kalogiros, PhD Student

Spyridon (Spyros) is currently a Ph.D. Student / Researcher and a member of Microelectronic Circuits Centre Ireland (MCCI), part of Tyndall National Institute in Cork, Ireland. He received his B.E. degrees in Electronic Engineering Education and in Electronic Engineering, in 2010 and 2011 respectively, both from the School of Pedagogical and Technological Education in Athens, Greece, and his M.S. degree in Electronic Physics / Radioelectrology from the Physics Department of Aristotle University of Thessaloniki, Greece, in 2015. He has held internship positions with COSMOTE S.A. in Athens, Greece, as a broadband network engineering trainee for the operation, maintenance and upgrade of its 3G mobile network, and with MCCI, where he has worked on an implantable and fully integrated biopotential acquisition chip, for cardiac pacing and sensing purposes. His current Ph.D. research is on the field of Delta-Sigma Analog-to-Digital Converters, aiming to develop new design guidelines and solutions for higher performance in terms of higher Figure-of-Merit, and therefore, to set higher state-of-the-art specifications, as imposed by the ongoing and increasing demand for even more efficient Analog-to-Digital Converters over the next few years."



Delta sigma Modulator Topology

Madhan Venkatesh, PhD Student

Current Research: Ultra low power design for biopotential acquisition.

Develop design techniques associated with Ultra low power design in deep sub-micron region.

Lead application: bio potential ADC.

A low voltage ADC (300mV - 500mV Supply) for Biomedical and IoT applications.

a. The objective here is to develop an ADC that can operate at low supply voltage,

b. With ENOB ~ 10, Sampling rate ~ 250ksps, power < 500nW.

c. Currently working on Comparator design to optimise the amount of power consumed by it.

The project is to develop a 12-bit ADC, on TSMC 65nm. TSMC 65nm uses a nominal core supply voltage of 1.2V. The goal of the project would be to develop circuits, comparator, sampling switches etc., which can operate at supply voltages of 500mV or lower. Reducing the supply voltage, significantly reduces the associated power consumption and enable a number of applications.

Research Topics: ultra low power SAR ADC design and tapeout (TSMG 65nm)

Education: MEngSc student

Hao Zheng, Research Assistant

Current Research: Implementation of high resolution data converter in 28nm CMOS processes for IoT application.

Research Jitter suppression techniques for converters.

Research Topics: CMOS Analog IC design, Mixed signal system modelling and design.

Education: Masters of Engineering Science, University College Dublin, Dublin, Ireland (2017)

Bachelor of Engineering Lanzhou University of Technology, Lanzhou, Gansu, China (2013

Anthony Wall, PhD Student

Current Research: A host of new sensing methodologies have emerged in electrochemistry and biological sensing over the past decade. The physics of many of these sensing topologies require charge-based rather than potential-based measurement. Thus there is a requirement for high resolution current-to-digital readout solutions. Anthony is researching the wide-bandwidth acquisition and digitisation of current signals using novel Analog-to-Digital conversion methods. Many of these sensors possess a large input capacitance which limits readout bandwidth and resolution. The research is focused on minimising the effects of input capacitance using circuit techniques. Of particular interest to Anthony is the Nanopore-based DNA sequencing method, which detects the sequence of a DNA strand as it passes through a nanometric hole. This device requires 10s of MHz bandwidth in order to effectively sequence DNA at pA level currents in the presence of 100s of pF of input capacitance.

MIDAS 3rd Level Project of the Year Winner for 'Design and Stimulation of an Analog Front End for Cancer Detection by Fluorescence Imaging'

UCC School of Engineering Joe Gantly Prize Winner for design of Sigma-Delta Converter while on placement with Cypress Semiconductor.

Research Topics:

- Current-Mode Sensor Interfaces
- High-Resolution Current Measurement
- Wide Bandwidth TIA Frontends
- Nanoscale Sensor Modelling
- Current-Mode ADC design
- Nanopore-based DNA Sequencing

Education: Anthony graduated from University College Cork with 1st Class Honors in the BE degree in Electrical & Electronic Engineering in 2018, and is currently pursuing the PhD degree with MCCI, University College Cork in the area of Mixed Signal Circuit Design.

Dr. Jeff Walling, Head of RF Transceivers

Dr. Walling received the B.S. degree from the University of South Florida, Tampa, in 2000, and the M.S. and Ph. D. degrees from the University of Washington, Seattle, in 2005 and 2008, respectively. He was employed at Motorola, Plantation, FL working in cellular handset development. He interned for Intel from 2006-2007, working on highly-digital transmitters and CMOS PAs and continued this research while a Postdoctoral Researcher at the University of Washington. He was an associate professor in the ECE department at University of Utah, where he continued his research on highly-digital TX, high power GaN PAs, power combining techniques and circuits for biological applications. Recently he has transitioned to Tyndall National Institute in Ireland, where he is the Head of RF Transceivers in the Microelectronic Circuits Centre Ireland. His current research focuses on high-efficiency transmitter architectures and digital-friendly PA design.

Dr. Walling has authored ~70 journal articles and conference papers, holds four patents with three pending. He received the Outstanding Teaching Award at University of Utah in 2015, the HKN Award for Excellence in Teaching in 2012, Best Paper Award at Mobicom 2012, the Yang Award for outstanding graduate research from the EE Department at University of Washington in 2008, an Intel Predoctoral Fellowship in 2007-2008, and the Analog Devices Outstanding Student Designer Award in 2006.

Seamus O'Driscoll, Principal Investigator

Current Research Focus: Power Systems integrated on-chip (PwrSoC) or in-package (PwrSiP).

- Point-of-load (POL), multi-phase, multi-level, resonant, hybrid switched-cap and isolated converter topologies.
- Laminated thin-film magnetic device design – on-die and embedded in substrate.
- Solenoidal and closed-core single phase and coupled inductor device design.
- Low voltage switch technologies – Bulk and SOI CMOS, VDMOS, LDMOS, GaN HEMT.
- Ultra-Low-Power (ULP) Control IC architecture and design.
- Gate driver technologies.
- Advanced mixed signal IC architecture.
- Low power inductive coupling.

M.E. by Research: High Dynamic Performance Induction Motor Control

Ruaidhrí Murphy, PhD Student

Current Research:

- GaN transistor based voltage regulator modules. GaN is a wide bandgap semiconductor capable of operating at high frequencies. There is potential to implement GaN in high efficiency small footprint voltage converters.
- Integrated inductors. Tyndall's magnetics group is a world leader in on-silicon inductors. Placing inductors on chip enables highly integrable packaging.
- Multi-phase coupled inductor design. Coupling inductors has DC flux cancellation advantages. Smart coupling topologies allows denser inductor solutions.

Research Topics:

- IC design
- Magnetics

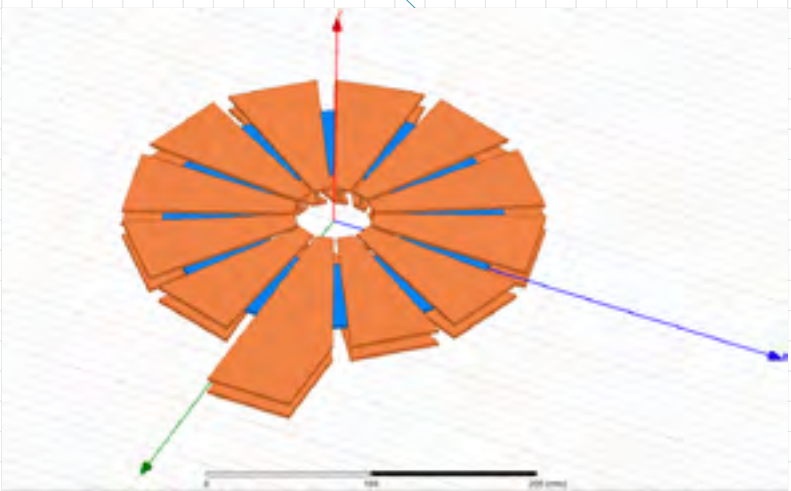
Education:

- Presentation Brothers College Cork
- University College Cork (BE Electrical & Electronic Engineering)

Past experience:

- 24GHz-60GHz Power Amplifier design
- mmWave Phased Array Antenna design
- Monolithic RFIC design

Embedded Planar Toroid Inductor Simulation Model



James McCarthy, Masters Student

Current Research: Ultra-Low Power Quasi-Resonant Buck-Boost Converter for application in energy harvesting solutions Acoustic Sensor mote for predictive maintenance system

Research Topics:

- Design, simulation and layout of the switch mode power supply's power path and gate drivers.
- Analog Mixed Signal Design on 180nm SOI
- State Space Modelling of the converter under all operating conditions
- Characterisation of the acoustic signature of a failing induction motor
- Design of an ultra-low power acoustic sensor for industry applications

Education:
Bachelor of Electrical and Electronic Engineering, University College Cork

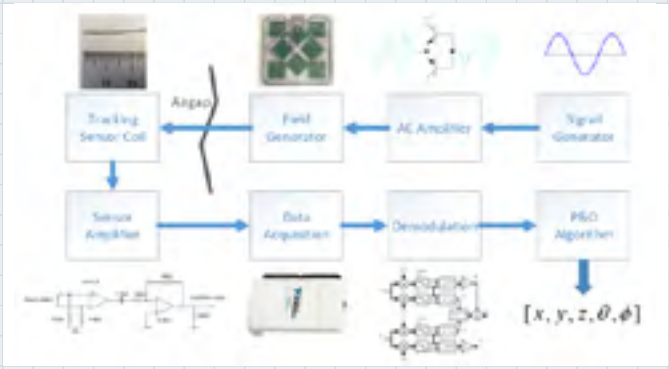
Dr. Pádraig Cantillon-Murphy

Has developed the first open-source electromagnetic tracking platform which can track medical instruments with sub-millimeter accuracy which we have chosen to make available free to the global research community (http://anser.io). Our next generation sensor technology will result from the current work at MCCI and we believe it will drive the platform to be commercially viable.

Education: He is a Lecturer in Electrical and Electronic Engineering at UCC, academic member of Tyndall National Institute & honorary faculty at l'Institut de Chirurgie Guidée par l'Image in Strasbourg. He has a first-class honours B.E. degree in Electrical and Electronic Engineering from UCC and Masters of Science and Ph.D. degrees at the Department of Electrical Engineering and Computer Science at Massachusetts Institute of Technology (MIT).

From 2008 to 2010, he was a postdoctoral research fellow with concurrent appointments at Harvard Medical School, Brigham and Women's Hospital, Boston and at the Research Laboratory of Electronics at MIT. He is principal investigator at the Biomedical Design Laboratory at UCC and Tyndall National Institute which explores novel device development in image-guided surgery and endoscopy.

His current research interests include magnets for surgery, electromagnetic tracking and navigation and surgical robotics. He is module coordinator for the UCC Biomedical Design module, an awarding-winning teaching program which couples medical and engineering students at UCC. He is a former Marie Curie fellow (2010-2014), a former MIT Whitaker fellow (2007-08), and a senior member of the IEEE. He has co-founded two start-up companies and is co-inventor on 6 patent applications.



Herman Alexander Jaeger, Post Doc Researcher

Current Research: My work focuses on design and development of electromagnetic navigation systems for image-guided medical interventions. The core technology allows physicians to track the locations of medical instruments within the human body without the use of cameras or radiology.

Research Topics:

- Developing electromagnetic navigation systems for non-line-of-sight tracking applications
- Characterisation and design of magnetic sensors for tracked medical instruments
- Investigating tracking algorithm and system calibration methods.

Education: BEng Hons Electrical & Engineering, University College Cork, 2014

UROP internship in The Hamlyn Centre, Imperial College London, 2014

MEngSc Electrical & Engineering, University College Cork, 2015

PhD Electrical & Engineering, University College Cork, 2018

Dr. Kilian O'Donoghue, Research Fellow

Dr. Kilian O'Donoghue is an electronic engineer with over ten years experience in medical electronic design. Kilian has worked in multiple start-up and early stage medical device companies in Ireland and Canada, developing core technologies in robotics, sensing, navigation and medical imaging systems. His current research includes electromagnetic tracking systems, on-chip magnetic field sensors as well as large scale MRI hardware design.

Research topics: Electromagnetics simulations, magnetic field sensing technologies, electromagnetic tracking, data acquisition systems, medical devices

Education: Kilian graduated with a first-class honours B.E. degree (2011) in Electrical and Electronic Engineering, before completing his Ph.D in Electromagnetic Tracking Systems (2014), both from University College Cork.

Manish Srivastava, PhD Student

My current research focuses on design and development of Integrated Amplifier for electromagnetic tracking system for image-guided medical instrument. The sensor allows to track the locations of medical instruments within the human body. Before joining here, I have worked in companies (Qualcomm and Synopsys) in the field of Mixed Analog circuit design and worked on high speed analog and digital circuit design. I also hold 4 issued and 5 filed US patents. Now, my interest in research and development propelled me to pursue a PHD in Data Converters and amplifier design.

Education: PHD Researcher in MCCI under supervision of Dr. Padraig Cantillon Murphy

Prof. Peter Kennedy

He received his BE (Electronics) degree from UCD in 1984, his MS and PhD from the University of California at Berkeley in 1987 and 1991, respectively, and the DEng from the National University of Ireland in 2010. He joined UCC as Chair of the Department of Microelectronic Engineering in 2000. He served as Dean of the Faculty of Engineering from 2003 through 2005 and as UCC's Vice-President for Research from 2005 to 2011. He moved to UCD in 2017. He has over 400 research publications (including four patents) in the fields of oscillator design, hysteresis, neural networks, nonlinear dynamics, chaos communication, mixed-signal test, and frequency synthesis. He has worked as a consultant for SMEs and multinationals in the microelectronics industry and is founding Director of the Microelectronics Industry Design Association (MIDAS Ireland) and the Microelectronic Circuits Centre Ireland (MCCI). He won UCC's Invention of the Year Award in 2011 and led the development of the US-Ireland Research Innovation Awards in 2014/15. He was made a Fellow of the Institute of Electrical and Electronic Engineers (IEEE) in 1998 "for contributions to the theory of neural networks and nonlinear dynamics and for leadership in nonlinear circuits research and education." He has served as Chair of the IEEE Gustav Robert Kirchhoff Award Committee and a member of the IEEE Fellows Committee. He has received many prestigious awards including Best Paper (International Journal of Circuit Theory and Applications), the 88th IEE Kelvin Lecture, IEEE Millennium and Golden Jubilee Medals, and the inaugural Royal Irish Academy Parsons Award in Engineering Sciences. In 2004, he was elected to membership of the The Royal Irish Academy and was made a Fellow of the Institution of Engineers of Ireland by Presidential Invitation. From 2005 to 2007, he was President of the European Circuits Society and Vice-President of the IEEE Circuits and Systems (CAS) Society (with responsibility for Europe, Africa and the Middle East). He was made a Fellow of the Irish Academy of Engineering in 2014. He was elected to membership of Academia Europaea in 2015. During 2012 and 2013, he was a Distinguished Lecturer of the IEEE CAS Society. He was elected Secretary for International Relations of the Royal Irish Academy in 2012. The following year, his RIA portfolio was expanded to include Policy. He has been President of the RIA since 2017.

Luca Avallone, PhD Student

Current Research: Bang-Bang Digital PLLs The key points of the research are:

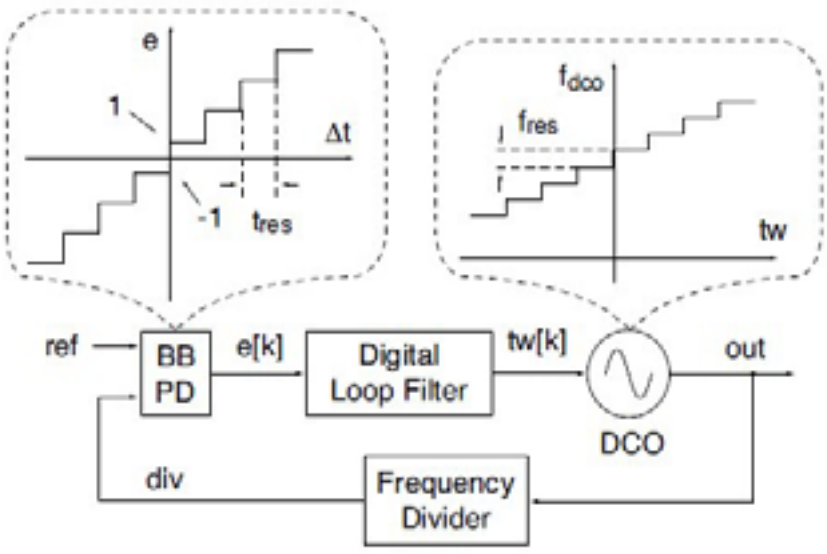
- Understanding the state-of-the-art of the structure identifying its main limits and problems;
- Development of a theoretical analysis of fractional-N Bang-Bang Digital PLLs;
- Implementation of a new solution focusing on the Binary Phase Detector (BBPD) and the Frequency Divider.

Research Topics: Advanced Frequency Synthesis, Digital Phase-Locked Loops

Education: Bachelor Degree in Electronic Engineering at University of Naples Federico II, 2014

Master Degree in Electronic Engineering at University of Naples Federico II, 2017

All-digital phase-locked loop with quantized phase and frequency



Dawei Mai, PhD Student

Current Research: High-Performance Fractional Frequency Synthesis. In the traditional phase-locked loop, the divider controller contributes to significantly to the output phase noise. The conventional multi stage noise shaping delta-sigma modulator divider controller (MASH-DDSM divider controller) with long input word length will induce periodic spurious tones in the output phase noise spectrum. To understand the phenomenon, provide insight into the cause of it and finally provide solutions to eliminate the periodic tones is the aim of the research.

Other components in the traditional analog and digital frequency synthesisers might pose performance limits to the performance of frequency synthesis. For example, the fractional input to the digitally controlled oscillator will introduce noise to the output phase noise. The exploration of those limits is another topic of the research.

Research Topics:

- Modelling of frequency synthesisers
- Spur elimination and noise reduction in fractional-N frequency synthesis

Education: Bachelor of Engineering (2015), University College Cork

Masters of Engineering (2018), University College Cork

Salvatore Galeone, PhD Student

Current Research: RTWOs as multiphase oscillators for frequency synthesisers

The Rotary Travelling Wave Oscillator is an oscillator topology based on a transmission line rather than a lumped resonator. The RTWO operates by propagating a travelling wave along a differential transmission line that is closed in a Möbius connection. The losses of the transmission line are restored by distributed CMOS amplifier stages.

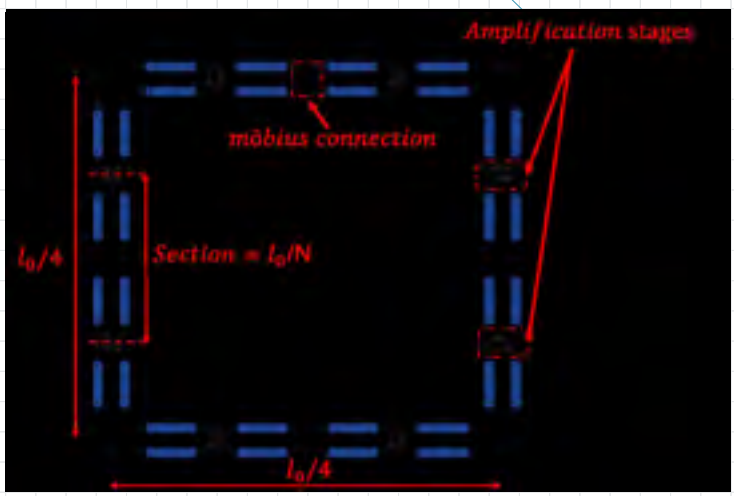
This oscillator topology is attractive for the intrinsic multiphase nature of the oscillator and its ability to operate a very high frequency with low phase noise and power consumption.

Research Topics: Oscillators, phase noise

Education: Salvatore holds a Bachelors' degree in Electronic Engineering from University of Pavia, Italy 2009

And Masters' degree in Electronic Engineering from University of Pavia, Italy, 2012

A rotary traveling wave oscillator is comprised of a Möbius connection of multiple sections of transmission line, with amplification stages in between to compensate for losses in the line.



Dr. Yann Donnelly, Post Doc Researcher

Current Research: Fractional-N Phase Locked Loops, which are employed throughout the communications industry, suffer from the appearance of spurious spectral components, "spurs", which limit performance. This research topic has elucidated the causes of spurs and investigates novel techniques for reducing this unwanted behaviour. Work to date has achieved best-in-class measured spur performance and further improvements are being investigated.

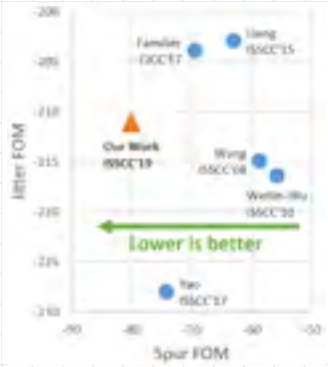
Research Topics:

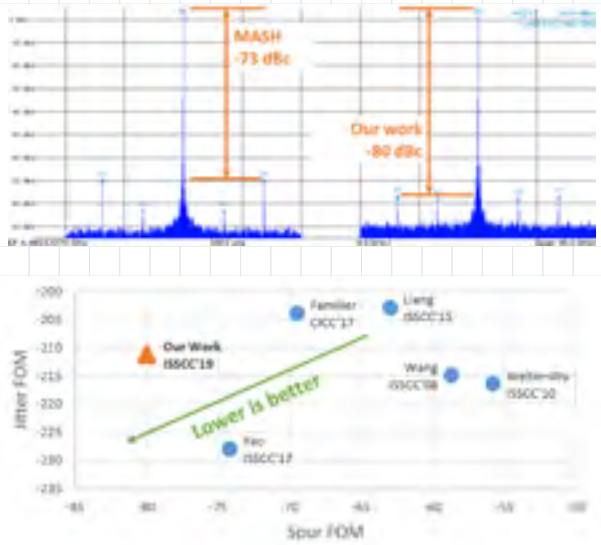
- PLL phase noise spectrum prediction
- Reduction of fractional-N spurs by modulator redesign
- Silicon verification through digital IC implementation

Education:

BE (Electrical & Electronic) – University College Cork, 2014

PhD (Microelectronics) – University College Cork, 2018





Valerio Mazzaro, PhD Student

Current Research:
Advanced fractional-N frequency synthesisers.

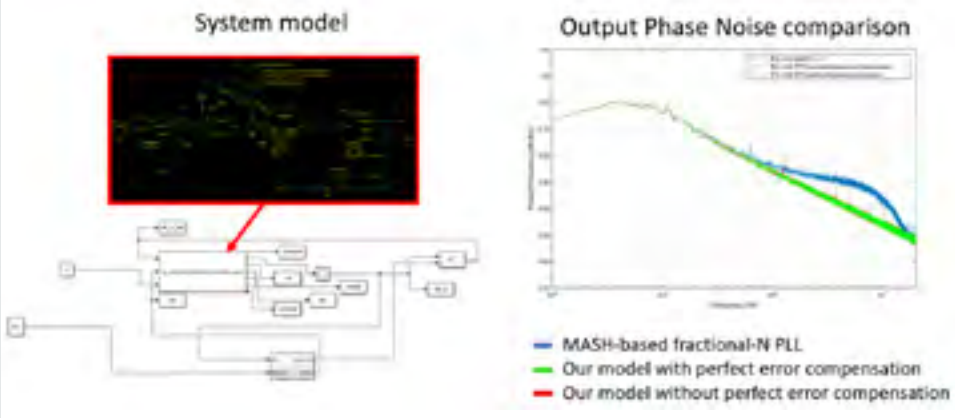
In fractional-N PLLs, increased phase noise comes from the error that the DDSM commits in quantising the fractional part of the division number.

The purpose of this project is to investigate the use of a digital-to-time converter (DTC) in the feedback path of an analogue PLL in order to implement a true fractional division. The phase noise performance of this solution will be analysed.

Research Topics:
Frequency synthesis, fractional-N PLL design, phase noise, DTC.

Education;
Bachelors Degree in Electronic Engineering at University of Naples Federico II, 14/12/2014

Masters Degree in Electronic Engineering at University of Naples Federico II, 28/9/2017



Prof. Bogdan Staszewski

In Sept. 2014 Prof Staszewski joined University College Dublin (UCD) as a Professor while still holding a part-time Professor position at TU Delft. Prior to 2014, he was at Delft University of Technology (TU Delft) in the Netherlands, where he held academic positions since 2009. He joined TU Delft in 2009 after 18 years in industry with diverse experience in microelectronics and communication systems. He is an IEEE Fellow for contributions to the digital RF communications systems. In 2012, he won the prestigious IEEE Circuits and Systems Industrial Pioneer Award. He has co-authored three books, six book chapters, 170 journal and conference publications, and holds140 issued US patents.

Professional experience: University College Dublin. Position Professor in the School of Electrical, Electronic & Communications Engineering. Carrying out research and teaching in the area of microelectronic circuit design; concentrating on frequency synthesis and RF using advanced CMOS for Internet-of-Things (IoT).

Delft University of Technology (TU Delft), Delft, the Netherlands. July 2009 to present. Carrying out research and teaching in the area of microelectronics, concentrating on frequency synthesis and RF using advanced CMOS.

From 1995 to 2009, he was with TI Dallas, where achievements included the invention and development of the Digital RF Processor (DRP) technology: A novel all-digital frequency synthesizer, all-digital RF transmitter and discrete-time RF receiver architecture that is suitable for the mainstream digital CMOS processes and presents a unique opportunity to build ultra low-cost and power-efficient single-chip radios. Developed a new digitally-intensive CMOS read channel architecture for magnetic recording hard-disk drives. Prior to TI he worked with Alcatel Network Systems, Texas from 1991 – 1995, included work in telecommunications systems, discrete analog and digital circuits, high-speed signal integrity, software algorithms.

Education: Ph.D. in Electrical Engineering, University of Texas at Dallas, USA. Thesis "Digital deep-submicron CMOS frequency synthesis for RF wireless applications," July 2002. M.S. in Electrical Engineering, University of Texas at Dallas, USA, with concentration in digital systems, Dec. 1992. B.S. in Electrical Engineering, Summa Cum Laude, University of Texas at Dallas, USA, with concentration in telecommunications, May 1991.

Reza Nikandish, Research Staff

Reza Nikandish received his Ph.D. degree in electrical engineering from the Sharif University of Technology, Tehran, Iran, in 2014. He is currently a researcher with University College Dublin (UCD), Ireland.

His current research interests include high-frequency integrated circuits and systems for wireless communications.

Dr. Nikandish is a recipient of the Marie Curie

Postdoctoral fellowship from the European Union's

Horizon 2020 Research and Innovation Programe

Amir Bozorg, Post Doc Researcher

Amir Bozorg is a PhD student at UCD since February 2016. He received the MSc degree from Amirkabir University of Technology (Tehran Polytechnic), Tehran, Iran in 2012 in Microelectronics.

He has been working on a new fully integrated discrete-time receiver (DTRx) for satellite applications and also, he is developing a new digitally assisted E/D-band TRx for automotive radars. He holds five patents and patent applications in the field of RF-CMOS design.

His research interests are:

1. Radio frequency/mm-wave transceiver design
2. Discrete-time receiver design
3. All digital phase locked loops and frequency synthesisers

Feifei Zhang, PhD Student

Current research: 2.4 GHz digital Cartesian RFDAC design

Research topics:
All digital modulator design;

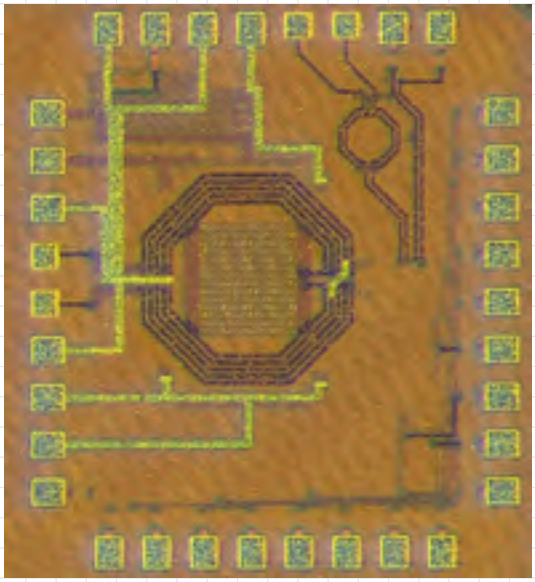
Class E/F power amplifier design;

FPGA implementation

Education: Joined Prof. Staszewski's group in Feb. 2017

Received MSc of Microelectronics in Beijing University of Technology, China in 2014;

received BSc of Navigation guidance and control in Beijing University of Aeronautics and Astronautics, China in 2011



Dr. Panagiotis Giounanlis, Post Doc Researcher

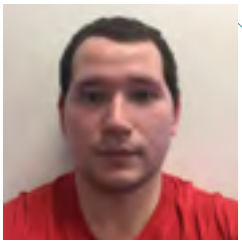
Panagiotis Giounanlis is a postdoc researcher at UCD since September 2017. His current work includes the development of numerical and analytical approaches for the modeling and simulation of nano-structures and semi-conductor coupled quantum-dots, the development of circuit equivalent models for electron transfer through multiple-quantum-dots, the characterisation and modeling of CMOS devices operation at low temperatures and others. He received his B.SC. degree in Physics and M.Sc. degree - Computational Physics Master of Science from Aristotle University of Thessaloniki (AUTh), Greece, in 2008 and 2011 respectively . In 2017, he received his Ph.D degree for his research on the modeling of non-linear effects for micro-scale devices (MEMS) and their application to reliability and control by the use of both numerical and analytical approaches. His research interests include: Modeling and simulation of micro/nano-scale devices and mixed-domain complex systems; Solid state Physics; Computational quantum mechanics.

Suoping Hu, PhD Student

He received his B.S. degree Integrated Circuit and Integrated System from Tianjin University, Tianjin, China in 2013, and M.S. degree in Electronic Science and Technology from the Shanghai Jiao Tong University, Shanghai, China, in 2016. He is currently pursuing his Ph.D. degree with the Department of Electrical and Electrotonic Engineering, University College Dublin, Dublin, Ireland.

His current interests include:
Phase-tracking receiver design

Ultra-low-power receiver design
Discreet-time circuit design



Viet Anh Nguyen, PhD Student

Viet Anh Nguyen has been a PhD student at UCD since September 2017, and in our group since 2016. He received his MSc degree in Electronic and Computer Engineering in 2017 and his BSc degree in Electronic and Communications Engineering in 2016, both from University College Dublin (UCD), Ireland.

His research interests are:

1. Analog and Mixed-Signal Integrated Circuit design,
2. Data converters,
3. Time-mode data conversion and signal processing.

Umanath R Kamath, PhD Student

Umanath R Kamath has been a part-time industry-based PhD student at UCD since September 2015. He is currently working at SLAC National Accelerator Lab, Menlo Park, CA. He was employed at Xilinx, Ireland between 2015-18.He received his MSc degree from Delft University of Technology, The Netherlands in 2012. He received his BSc degree in Electronics and Communication Engineering from M.S. Ramaiah Institute of Technology, Bangalore, India in 2009. Previously he has held positions at Cypress Semiconductors Ireland, CMOSIS Belgium, IMEC Belgium and Honeywell India.

Hongying Wang, PhD Student

Current Research: Digital-intensive low-power ADC design with the nanoscale CMOS technology for IoT application and Cryogenic circuit design for the Quantum computer.

Research Topics:

- Digital intensive Level Crossing Sampling ADC design
- Passive Delta Sigma ADC design
- Single Electron detector design for Quantum Computer
- Front-end circuit design for cryogenic application

Education: She received her MSc and BSc degrees in Microelectronics from Harbin Institute of Technology, Heilongjiang Province, China in 2015 and 2013, respectively. She is currently pursuing her PhD degree in Microelectronics at University College Dublin (UCD), Dublin, Ireland.

Yizhe HU, PhD Student

Yizhe Hu was born in Chenzhou, Hunan, China. He received his B.Sc. degree (summa cum laude) in electronic engineering from Harbin Institute of Technology, Harbin, China, in 2013. He is currently pursuing his PhD degree in microelectronics at University College Dublin, Dublin, Ireland. From 2013 to 2014, he was with Fudan University, Shanghai, China, where he was involved in the RFIC design. From May 2016 to Oct 2017, he had been consulting for the PLL Group of HiSilicon, Huawei Technologies, Co., Ltd., Shenzhen, China, designing 16-nm DCOs and ADPLLs. His research interests include RF/mm-wave integrated circuits and systems for wireless communications. Mr Hu has served as a reviewer for the IEEE Journal of Solid-State Circuits and TCAS-I/II.

Dennis M. Andrade Miceli, PhD Student

University College Dublin

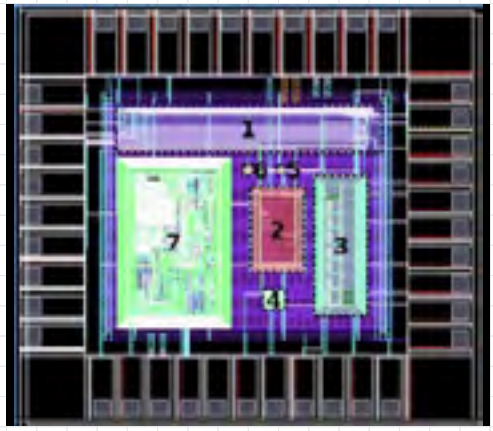
Current Research: Sub-Vt full-custom digital IC design for ULP applications in bulk and FD-SOI, including PVT analysis and real-time adaptive compensation mechanisms in time-domain circuits. FD-SOI MOSFET characterisation and modelling in cryogenic temperatures for Quantum Computing applications.

Research Topics:

- Sub-Vt (ULP) digital ICs
- FD-SOI characterisation and modelling
- PVT compensation
- Quantum Computing

Education:

- Ph.D. Candidate by University College Dublin. Dublin, Ireland. 2016 to present
- Third level courses in Electronic Engineering and Junior Research Certification by Technical University of Catalonia. Barcelona, Spain. 01/2007 – 03/2011, 08/2013 – 08/2014
- M.Sc. Electronic Engineering, National Institute of Astrophysics, Optics and Electronics. Puebla, México. 09/2000 – 02/2003
- Industrial Electronic Engineering, Instituto Tecnológico de Veracruz. México. Sept 1991 - Dec 1997



Hieu Minh Nguyen, PhD Student

Current Research: Hieu Minh Nguyen is now focus on all-digital RF Digital-to-Ananlog Converter and Transmitter for low-band 5G application.

Research Topic:

- Switched-Capacitor Power Amplifier (Switching Class)
- Hybrid Data Converter for Transmitter
- All Digital Charged-Sharing RFDAC
- Power Combination network for high-efficiency Transmitter.
- Radio Frequency, Analog and Mixed-Signal IC Design.

Education: Hieu Minh Nguyen is a PhD student at UCD since November 2017. He received his BSc & MSc degree in Electronic Engineering in Ho Chi Minh City University of Technology in 2016 and 2014. During 2013–2014, he joined Integrated Circuit Design Research and Education Center where he studied and designed the delta-sigma converter. From 2015 – 2016, he was with Uniquify to design the PHY Interface and SERDES system.

Mohamed Shehata, PhD Student

Mohamed Shehata received his B.Sc. and M.Sc. degrees in electrical engineering from Ain Shams University, Cairo, Egypt in 2009 and 2016 respectively. He is currently pursuing his Ph.D. degree in microelectronics from University College Dublin, Dublin 4, Ireland. From 2009 to 2016, he was with MEMS Vision, Cairo, Egypt as analog/mixed-signal IC design engineer where he was involved in designing of VCOs and PLLs. In 2016, he joined Xilinx, Dublin, Ireland as analog design engineer. Since 2017, he has been with Analog Devices, Limerick, Ireland as an RF design engineer. His current research interests include RF and millimeter-wave integrated circuits and systems for wireless communications and automotive radars. Mr. Shehata has served as a reviewer for the IEEE European Solid-State Circuits Conference (ESSCIRC) and IEEE International Symposium on Circuits and Systems (ISCAS) since 2017.

Dr. Teerachot Siriburanon, Post Doc Researcher

Teerachot Siriburanon is currently, an Assistant Professor at University College Dublin, Ireland, following his Marie Sklodowska-Curie Individual Fellowship Program received in 2017 which supported his research on Wave-Locked Loop for Frequency Synthesis (WLL). He won the prestigious IEEE Solid-State Circuits Society Predoctoral Achievement Award 2015-2016.

Research Topics: mm-Wave oscillators and frequency generations

low-power, high-performance ADPLL

mm-wave transmitter/receiver for 5G communications and beyond

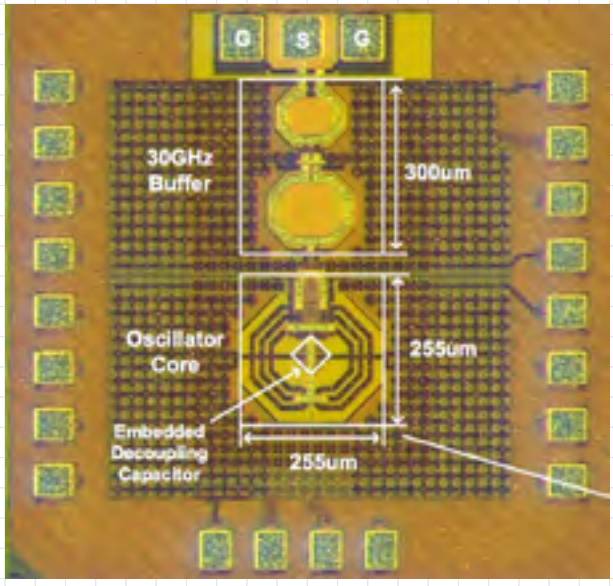
Education: 10/2012- 02/2016 Doctor of Philosophy (Ph.D.)

Department of Physical Electronics, Tokyo Institute of Technology, Japan

Thesis Title: "Low-Power Low-Jitter Frequency Synthesiser for High-Speed Wireless Communication"

10/2010 - 09/2012 Master of Engineering (M.E.)

Department of Physical Electronics, Tokyo Institute of Technology, Japan



Prof. Anding Zhu

Anding Zhu received his Ph.D. degree in electronic engineering from University College Dublin (UCD) in 2004. He has been working in UCD since 2005, first as a Post-doc, then a Lecturer, an Associate Professor and now he is a Professor in the School of Electrical and Electronic Engineering. His research interests are in the area of nonlinear modelling and characterisation of RF circuits and systems with a particular emphasis on digital linearisation of RF power amplifiers for wireless communications. He has published over 100 peer-reviewed papers and received research funding from various sources including awards from Science Foundation Ireland (SFI), European Space Agency (ESA), Enterprise Ireland (EI) and industry donations.

Prof. Zhu collaborates with many universities and international companies. He was appointed as a Guest Research Fellow at University of Aveiro, Portugal in 2006 and worked as a Visiting Scholar at University of California at San Diego (UCSD) in 2007. Prof. Zhu was undertaking a sabbatical leave working as a Visiting Assistant Professor at Stanford University from January to June 2013. He is currently with the RF & Microwave Research Group at UCD and he is the Director of the IoE2 Lab, a multi-disciplinary research laboratory focusing on developing enabling technologies and making scientific breakthroughs for next generation Internet of Things (IoT) and future (5G) communication networks. Prof. Zhu is a Funded Investigator in the SFI Research Centre for Future Networks and Communications - CONNECT, where he is particularly working on physical layer network-aware intelligent radio access nodes in collaboration with Xilinx, Analog Devices, MA-COM and Synopsys.

His current research includes behavioural modelling and digital linearisation of RF power amplifiers, high-frequency non-linear circuit and system simulation, wireless transmitter architectures, RF-DAC, digital signal processing and nonlinear system identification algorithms.

Mr. Brian Keogh, PhD Student

Current Research: Wideband Self Interference Cancellation for 5G Full-Duplex Radio.

Effective Self Interference Cancellation (SiC) is an important consideration for future 5G radio. If it can be successfully implemented, SiC has the potential to double spectral efficiency for certain 5G applications.

Research Topics: Fig. 1 Radio Architecture for Full-Duplex

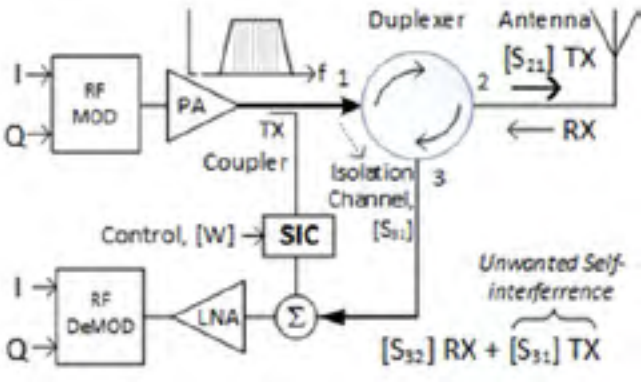
Full-duplex operation is considered difficult to implement because the isolation between the transmit (TX) and receive path (RX) is not perfect. Current solutions take a copy of the TX signal and use this copy to cancel the unwanted self-interference as shown Fig. 1.

The research topics focus on novel methods to extract time delayed copies of the TX signal so that advanced stochastic algorithms can precisely match the frequency domain response of the channel.

Education: BEng (Hons) in Electronic Engineering, MSc in Computer Science.

Lecturer in IT Tallaght, Department of Electronic Engineering.

Current PhD studies are supported by UCD and SFI.



Samaneh Sadeghi Maraht, PhD Student

Current Research: My research is mainly focused on designing small size antenna with high directivity/ gain and wide bandwidth that operates in the frequency of mm wave range (30 GHz-300 GHz).

Research Topics: mm-wave antenna for high speed data transmission

Education: University College Dublin (Current PhD student), 2017-

K.N.Toosi University of technology (MSc), 2015

Guilan University (BSc), 2012

Dr. Barry Cardiff

Current Research: Digitally-Assisted Analog Design
Embedded systems (mainly for biomedical devices)
Compressed sensing applications – currently focused on cost & power reduction of 5G systems.
Flexible waveforms for future wireless communications
Physical Layer Network coding in relay systems – design and analysis

Education:

- 2011: PhD Electronic Engineering from UCD.
- Thesis Title "Design Techniques for Vector Systems in Communications"
- 1995: M.Eng.Sc in Electronic Engineering from UCD.
- Thesis Title: "Digital Receiver Techniques in Mobile Communications"
- 1992: B.Eng in Electronic Engineering from UCD.

Mr. Armia Salib, PhD Student

Current Research: Digitally-Assisted Analog Design:
We are designing new methods to augment traditional ADCs with digital techniques in order to improve the overall circuit performance. This can result in smaller, cheaper, lower-power parts with equivalent conversion performance (e.g. ENOB), or conversely in high-end applications can allow very high conversion performance targets to be achieved. This work is being conducted in collaboration with local industry.

Research Topics:
Digitally-Assisted Analog Design

Education:
2014: M.Sc. in Electrical Engineering, from Ain Shams University, Egypt.

Thesis Title: Digital Calibration for Time Interleaved Analog to Digital Converter

2007: B.Sc. in Communications & Electronics, Alexandria University, Egypt.

Dr. Brendan Mullane

Dr. Mullane joinedThe University of Limerick (UL) in 2003, after spending more than 10 years in industry, mostly as a VLSI designer. He received his Ph.D. in Electronic Engineering from UL in 2010. His current role is Senior Research Fellow in the Dept. of Electronic and Computer Engineering. To-date, he has published over 35 peer-reviewed articles, authored one book-chapter, holds 8 invention disclosures and has been granted four US patents. His research interests include high performance, low-power VLSI for signal processing, DSP/CPU and data converters applications.

Professional experience: Senior Research Fellow, Department of Electronic and Computer Engineering, University of Limerick. Carrying out research and supervision/teaching roles in the area of digital signal processing and VLSI design.

From 1992 to 1995, he worked with ALPS Electric (Fukushima/ Japan) working on TV tuner electronics and C++ software design. From 1995 to 1996, he was with the start-up Silicon Systems Design (Dublin) developing DSP core IP for high-end audio applications. Prior to joining UL, he worked with the ASIC design company, LSI Logic (Tokyo/ Japan) from 1996 to 2002 as a senior IC designer developing digital system-on-chips for DVDs and other customer applications supporting ARM cores.

Research experience: During his time at UL, he has been Principal Investigator (PI) on a number of significant research projects involving data conversion and signal processing applications. He gained his Ph.D. in the area of data converter built-in-self test. He has received research-funding awards from Enterprise-Ireland and Science Foundation Ireland while also achieving various donations through collaborations with industry helping to train and graduate Ph.D./Masters researchers.

Dr Mullane is also a Funded Investigator in the SFI Research Centre for Future Networks and Communications – CONNECT where he is working in collaboration with industry on advanced signal processing techniques to overcome unwanted noise sources in D/A converters.

He is currently with the circuits and systems research group at UL developing technology for next generation connected Internet of Things (IoT) devices that require safety critical signal monitoring capabilities. Current research include digital assisted signal-processing techniques for data converters, test and on-chip evaluation of signals enabling feature extraction and analysis. He is interested in the application of this research to areas such as integrated healthcare and brain monitoring devices.

Shantanu Mehta, Research Staff

Current Research: My current research is focused on dynamic element matching calibration techniques to overcome non-linear error sources in current-steering Digital to Analog Converters (DACs).

The aim is to increase the design performance using digital signal processing techniques attached to the analog D/A converter design. My research activities also included design of a tri-level current-steering D/A converter design for use in continuous time ADCs.

Research Topics:
High-speed ADC and DAC's.

Digital Signal Processing.

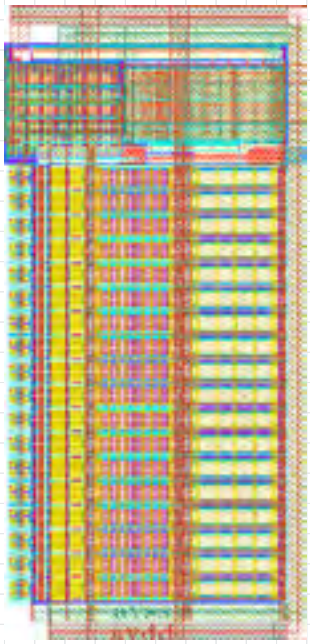
Sigma Delta ADC and DAC'S.

Dynamic Element Matching Techniques.

Education:
Currently pursuing Ph.D. in Microelectronics from University of Limerick, Ireland.

M. Tech, VLSI Design from Vellore Institute of Technology, India.

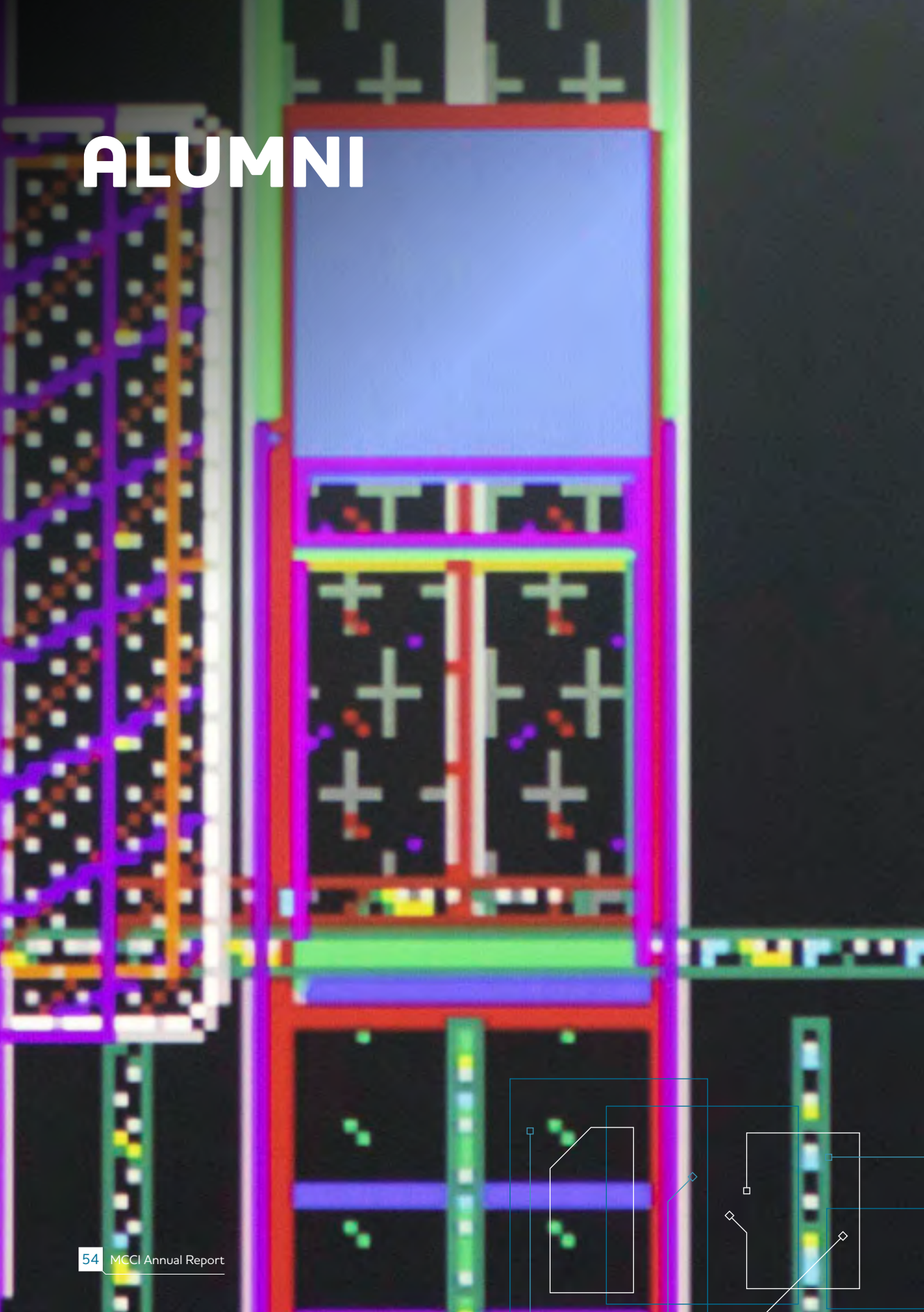
B.E., Electronics & Telecommunications from Walchand Institute of Technology, India.

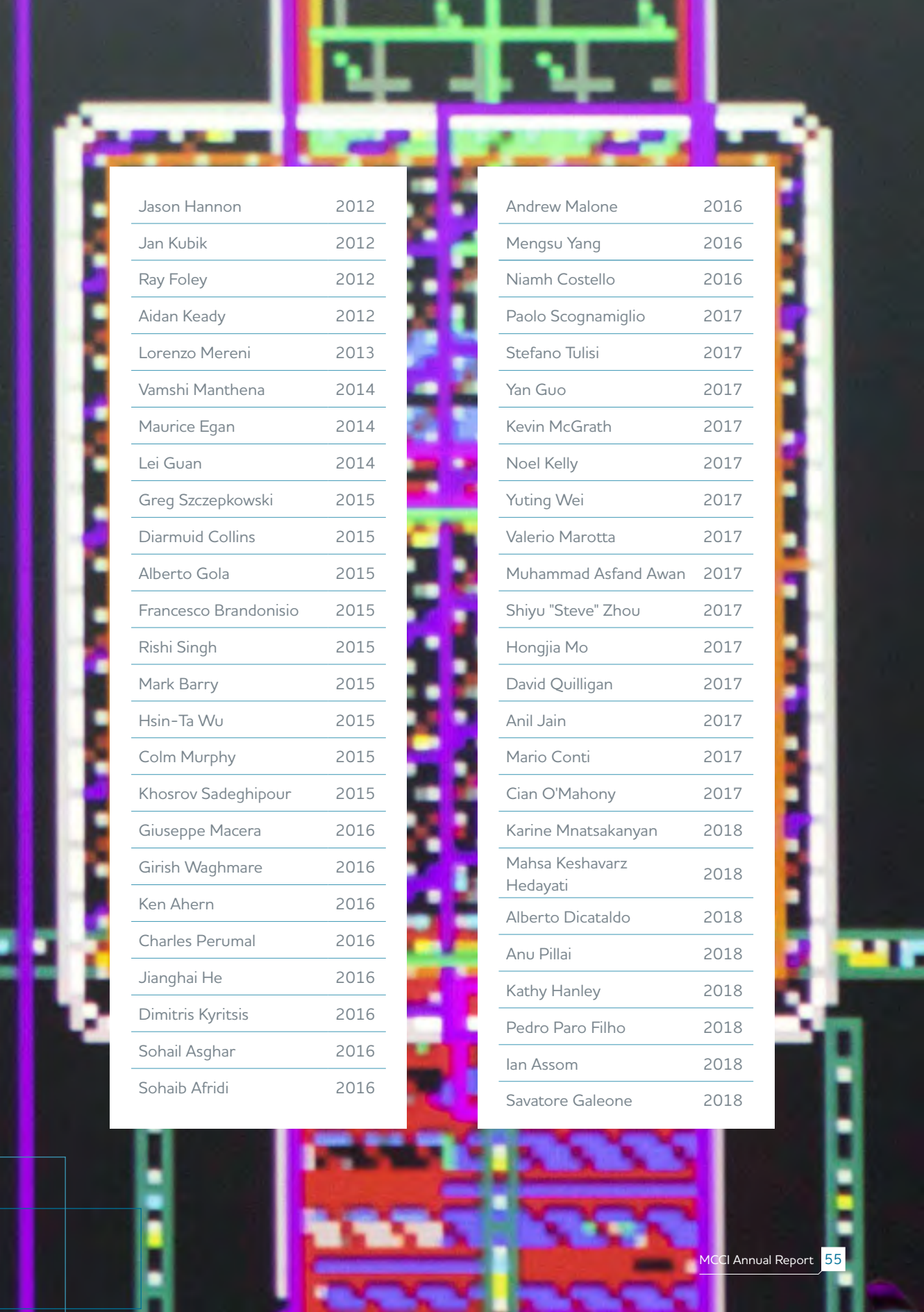


Dr. Emanuel Popovici

Emanuel Popovici(SM-IEEE, M-ACM) is a Senior Lecturer in Electrical and Electronic Engineering at University College Cork(UCC). Emanuel received a Dipl. Ing. Degree in Computer Engineering (with a major in Hardware Design) from the University Politehnica Timisoara, Romania in 1997 and a PhD in Microelectronics from University College Cork (National Microelectronics Research Centre) in 2002 respectively. Between 1997 and 2001 he did his research on efficient algorithms and hardware architectures for finite field arithmetic and error control coding within the National Microelectronics Research Centre, Ireland. Emanuel is the director of the award winning Embedded.Systems@UCC research group(motto of the group is Engineering Inspired by Life). The group has built a distinguished publishing record of more than 200 papers on coding and cryptography algorithms and architectures, ultra-low power arithmetic, EDA for digital circuits, security and reliability in the context of SoC/NoC and in wireless embedded systems, including sensor networks(WSN). Taking a truly interdisciplinary approach in research, the group has received more than 30 national and international awards and distinctions from organisations including IEEE, ACM, IET, MIDAS Ireland, IBM, Irish Lab Awards, etc. He mentored student teams who won 3 prizes in the prestigious IEEE/IBM Smarter Planet Challenge (first prize in 2011 project iCARE: improved healthcare for disadvantaged communities, second prize in 2013 project U-Play: unified networks and interfaces for playing with toys, first prize in 2014 project To Bee or not to bee=TRUE: from the beehive to the cloud and back). In 2016 his group received the Irish Engineering Lab of the Year award and in 2018 he received the Collaboration achievement award (Brain Stethoscope project together with INFANT Centre, Embedded. Systems@UCC and Tyndall)

ALUMNI





Jason Hannon	2012
Jan Kubik	2012
Ray Foley	2012
Aidan Keady	2012
Lorenzo Mereni	2013
Vamshi Manthena	2014
Maurice Egan	2014
Lei Guan	2014
Greg Szczepkowski	2015
Diarmuid Collins	2015
Alberto Gola	2015
Francesco Brandonisio	2015
Rishi Singh	2015
Mark Barry	2015
Hsin-Ta Wu	2015
Colm Murphy	2015
Khosrov Sadeghipour	2015
Giuseppe Macera	2016
Girish Waghmare	2016
Ken Ahern	2016
Charles Perumal	2016
Jianghai He	2016
Dimitris Kyritsis	2016
Sohail Asghar	2016
Sohaib Afridi	2016

Andrew Malone	2016
Mengsu Yang	2016
Niamh Costello	2016
Paolo Scognamiglio	2017
Stefano Tulisi	2017
Yan Guo	2017
Kevin McGrath	2017
Noel Kelly	2017
Yuting Wei	2017
Valerio Marotta	2017
Muhammad Asfand Awan	2017
Shiyu "Steve" Zhou	2017
Hongjia Mo	2017
David Quilligan	2017
Anil Jain	2017
Mario Conti	2017
Cian O'Mahony	2017
Karine Mnatsakanyan	2018
Mahsa Keshavarz Hedayati	2018
Alberto Dicataldo	2018
Anu Pillai	2018
Kathy Hanley	2018
Pedro Paro Filho	2018
Ian Assom	2018
Savatore Galeone	2018

IP REGISTER SUMMARY

IP CREATED, VALUED AND READY FOR LICENSING

Description	Owning PRO	Research Lead
A 100dBFs SFDR Band-Pass ΣΔ Current-Steering DAC in UMC 90nm	UL	Brendan Mullane
0.32mm^2, 0-6GHz, 4ps rms Multi-band LC VCO PLL	NUIM	Ronan Farrell
A continuous time front end for ADC in 28nm SOI	UL	Tony Scanlan
0.35µm CMOS Instrumentation Amplifier	UCC	Ivan O'Connell
0.35µm CMOS nano-watt 32.768KHz always-on clock generator	UCC	Ivan O'Connell
0.35µm CMOS nano-watt 12b SAR ADC utlizing a 32KHz clock & converting at 800Hz	UCC	Ivan O'Connell
0.35µm CMOS nanowatt differential input & output bandpass filter	UCC	Ivan O'Connell
Digital Control from Innovation partnership	UL	Mark Halton
Digital Control synthesis tool from CFTD	UL	Mark Halton
0.35µm CMOS thoracic impedance circuit used to infer respiratory rate	UCC	Ivan O'Connell
0.35µm CMOS nanowatt voltage reference & bias current circuit. Vref is independent of temperature & power supply variation	UCC	Ivan O'Connell
0.35µm CMOS low power PMIC that uses an external inductor to increase a Vin (varying from 2V to 3V) to a higher Vout, programmable up to 18V.	UCC	Ivan O'Connell
0.35µm CMOS Pacing Block which charges a Pace Capacitor via a current source. The Pace Capacitor is discharged in a controlled manner to force the heart to beat.	UCC	Ivan O'Connell
0.35µm CMOS Neurostimulation pulse generator can operate up to 18 Volts, and delivers biphasic currents	UCC	Ivan O'Connell
0.35µm CMOS Digital Block for controlling Pacing or Neurostimulation	UCC	Ivan O'Connell

IP CREATED

Owning RPO	Research Lead	Category	IP Block	Description	Status
UCC	Peter Ossieur	PAM-4 CDR	Components for analog phase locked loop	STM 65nm CMOS, Phase detector, charge pump, analog filter, high-speed digital divider circuit with few programmable divider settings	Silicon Proven
UCD	Anding Zhu	ADC	Algorithm	Volterra-based RLS (Recursive Least-Square) algorithms for Digital Post-Correction of ADCs	
UCD	Anding Zhu	ADC	Algorithm	Algorithms for Non-uniform Analog Interpolated Multichannel Digital Post-Correction for Time-Interleaved ADCs	
UCC	John Doyle	AMS	Current Sense	0.35µm CMOS High-side Current Sensor	Silicon Proven
UCC	Kevin McCarthy	Power Management	DCDC	30MHz DC-DC Converter with Integrated Magnetics	Silicon Proven
UL	Tony Scanlan	ADC	ADC	65nm HiCOSANT SAR ADC with Novel Calibration	Silicon Proven
UCC	Peter Kennedy	PLL	Freq Div	Divide-by-three Injection-Locked Frequency Divider	
UCC	Ivan O'Connell	RF	Voltage Controlled Oscillator	High-performance Voltage Controlled Oscillators in a SiGe BiCMOS technology	Silicon Proven
UCC	Ivan O'Connell	RF	Varactor	High Q Varactor for High-performance Voltage Controlled Oscillators in a SiGe BiCMOS technology	Silicon Proven
UCC	Ivan O'Connell	ADC	Thermal noise reduction	Reduction of Sampled KT/C Thermal Noise for ADC	Simulation

Owning RPO	Research Lead	Category	IP Block	Description	Status
UCC	Ivan O'Connell	AMS	TIA	3.3V 0.35µm transimpedance amplifier	GDS
UCC	Ivan O'Connell	AMS	Active Quench Circuit	Active quench circuit for use with Single Photon Avalance Diode	GDS
UCC	Ivan O'Connell	AMS	Bandgap	3.3V supply 0.35µm 1.2V Bandgap Reference circuit	GDS
UCC	Ivan O'Connell	Digital	Ring Oscillator	0.35µm 666MHz ring oscillator with divide-by-32	GDS
UCC	Ivan O'Connell	AMS	SPAD readout	0.35µm single photon avalance diode pixel read out circuit	GDS
UCC	Ivan O'Connell	AMS	TDC	0.35µm time-to-digital converter	GDS
UCC	Ivan O'Connell	Digital	Standard-cells	0.35µm digital standard cells	Layout
UCC	Ivan O'Connell	Biomedical	Pace controller circuit	0.35µm CMOS low power Cardiac Pace Controller which interfaces with sense channels & microprocessor to handle multi-mode pacing	Silicon Proven
UCC	Ivan O'Connell	Clocking	Clock generator	0.35µm CMOS low power clock oscillator that generates a freq stable across power supply range, with adjustable pulse width	Silicon Proven
UCC	Ivan O'Connell	Biomedical	Chip	0.35µm CMOS low power chip that includes Atrium Sense, Ventricle Sense, Thorasic Impedance Sense, Atrium Pace, Ventricle Pace, Neurostimulation, Hysteric Boost Block and Real time Clock to enable Rate Responsive heart pacing	Silicon Proven

Owning RPO	Research Lead	Category	IP Block	Description	Status
UCC	Ivan O'Connell	Biomedical	Chip	0.35µm CMOS low power chip that includes Atrium Sense, Ventricle Sense, Atrium Pace, Ventricle Pace, Neurostimulation, Hysteric Boost, Real time Clock and Pace Controller to enable heart sensing and pacing without the intervention of a micro controller	Silicon Proven
UCC	Ivan O'Connell	ADC	Capacitive-to-Digital converter	0.35µm CMOS Oversampled Sigma Delta ADC with extended Input Range	Silicon Proven
UCC	Ivan O'Connell	Digital	Asynchronous I2C Slave Interface	Asynchronous I2C Slave Interface	Silicon Proven
UCC	Ivan O'Connell	Sensor	Layout	Several permutations of Interdigitated Sensor Structure Test Chip	Silicon Proven
UCC	Ivan O'Connell	ADC	Sigma Delta Modulator	Sigma Delta Modulator on XFAB 0.35µm	GDS
UCC	Ivan O'Connell	Biomedical	DNA Sensor Chip	0.35µm CMOS DNA Sensor Chip containing a high-resolution sigma-delta Capacitive-to-Digital converter, I2C Interface, bandgap reference, bias generator, 1MHz oscillator, Power-on-Reset circuits, EEPROM memory for ID coding, chip tracking, and sensor calibration coefficients.	Silicon Proven
UCC	Ivan O'Connell	ADC	SAR ADC Chip	28nm 13 ENOB noise-shaped SAR ADC	Silicon Proven
UCC	Ivan O'Connell	ADC	SAR ADC Chip	28nm 15 ENOB noise-shaped SAR ADC	GDS

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MCCI RESEARCH PUBLICATIONS

1. J. Du, Y. Hu, T. Siriburanon, and R. B. Staszewski, "A 0.3 V, 35% tuning-range, 60 kHz 1/f3-corner digitally controlled oscillator with vertically integrated switched capacitor banks achieving FoMT of -199 dB in 28-nm CMOS," (CICC), Apr. 2019
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8. K-F. Un, F. Zhang, P-I. Mak, R. P. Martins, A. Zhu, R. Bogdan Staszewski. "Design Considerations of the Interpolative Digital Transmitter for Quantization Noise and Replicas Rejection", (TCAS-II), March 2019
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10. K. Pomorski, P. Giounanlis, E. Blokhina, R. B. Staszewski, D. Leipold, "Modeling quantum universal gates in semiconductor CMOS," Scalable Hardware Platforms for Quantum Computing, Jan. 2019
11. A. Salib; M. F. Flanagan; B. Cardiff, "A Generic Foreground Calibration Algorithm For ADCs with Nonlinear Impairments", (TCAS-I), 2018
12. P. Chen, X. Huang, Y. Chen, L. Wu, R. Staszewski. "An On-Chip Self-Characterization of a Digital-to-Time Converter by Embedding it in a First-Order ΔΣ Loop", IEEE Transactions on Circuits and Systems I (TCAS-I) Aug 2018
13. N. Pourmousavian, FW Kuo, T. Siriburanon, M. Babaie, R. Staszewksi. "A 0.5-V 1.6-mW 2.4-GHz Fractional-N All-Digital PLL for Bluetooth LE With PVT-Insensitive TDC Using Switched-Capacitor Doubler in 28-nm CMOS", IEEE Journal of Solid-State Circuits, Vol 53 Issue 9, Sep 2018 (JSSC)
14. Y. Hu, T. Siriburanon, R. Staszewksi. "A Low-Flicker-Noise 30-GHz Class-F23 Oscillator in 28-nm CMOS Using Implicit Resonance and Explicit Common-Mode Return Path", IEEE Journal of Solid-State Circuits, July 2018 (JSSC)
15. D. Mai and M.P. Kennedy. "A Design Method for a Nested MASH-SQ Hybrid Divider Controller for Fractional-N Frequency Synthesizers", IEEE Trans. Circuits and Systems-Part I, 65(*): April 2018. (TCAS-I)

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24. C. Wilson; J. King, "Ensuring Charge Conservation in GaN HEMT Large Signal Model", (EuMIC), 2018

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37. F. W. Kuo, N. Pourmousavian, T. Siriburanon, R. Staszewski, "A 0.5V 1.6mW 2.4GHz Fractional-N All-Digital PLL for Bluetooth LE with PVT-Insensitive TDC using Switched-Capacitor Doubler in 28nm CMOS," IEEE Symposium on VLSI Circuits, June 2017

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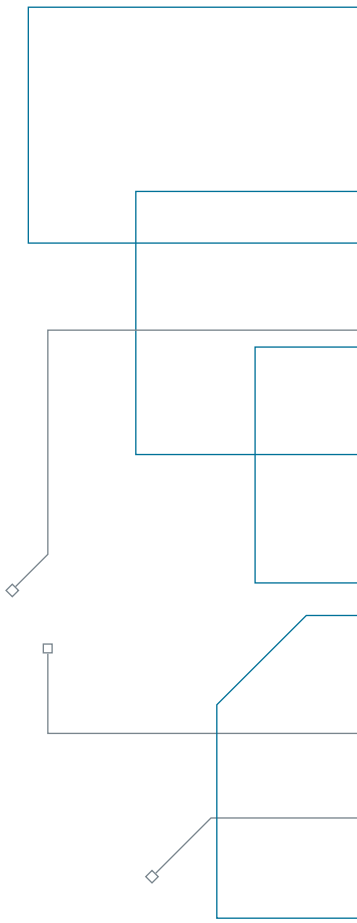


CASE STUDIES

ADC IP GENERATION

Overview

Rohm/Powervation designs and delivers energy-efficient solutions for power-supply systems used in networking, storage and computing applications. The company's digital power IC technology brings fully automatic adaptive control to DC/DC conversion for the first time, in a reliable package that reduces design complexity and cost, increasing power-supply performance and accelerating time to market.

Challenges

A critical component of Rohm power-supply controller solution, is an integrated 11 bit Analog to Digital Converter (ADC), which is used to provide precision measurement of the load voltage, load current and other internal system parameters. Rohm had identified the ADC as one of the blocks which limits the performance that can be achieved with their current generation of products. To enable their fourth generation product family, a significant performance improvement in the ADC performance was essential. They came to MCCI to develop a state of the art ADC, which would enable a significant performance improvement in their next generation of products.

Benefits of Collaboration

Rohm/Powervation engaged with MCCI under an Enterprise Ireland Innovation Partnership agreement, to research and design a new ADC which met the requirements of their application. MCCI's research expertise was leveraged to deliver significant improvements in the ADC signal bandwidth and latency, increasing the efficiency of the power supply as well as reducing the bill of materials. The ADC performance delivered by MCCI enables new market segment opportunities within the power solutions industry for Rohm.

Research Outcomes

Since engaging with MCCI, Powervation have been acquired by multinational electronics company Rohm. The research collaboration enabled the company to develop new IP as well as attracting top engineering talent. This was an important outcome for the design group at Rohm. The successful collaboration and engagement in the MCCI ecosystem, who have established a track record in attracting world class researchers and transferring them to industry.

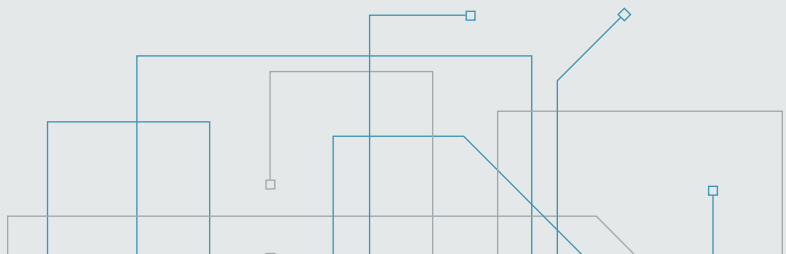
ROHM SEMICONDUCTOR

"Engaging with MCCI enabled the external validation from the MCCI research team of the ADC requirements and specifications for the intended application. In addition to the IP licensed as a result of the project, we were delighted to have the ability to identify new talent during the engagement, who were hired once the project was completed".

John Ryan, VP Engineering, Rohm Semiconductor.

The engagement with Rohm is another example of creating real impact from research. An important value add of the centre is the creation and commercialisation of IP to benefit industry. We were delighted to see Rohm look to hire some of the researchers involved in this project, gaining from knowledge transfer through researchers in addition to the digital assets created during the research".

Donnacha O'Riordan, MCCI, Executive Director.



SMART AGRI SENSOR INTERFACE RESEARCH

Overview

AltraTech is an early stage start-up company developing disruptive platform technologies, which brings biotechnology, semiconductors and genetics together; to address needs in the emerging Smart Agri markets. A portable diagnostics kit addresses the emerging worldwide trend of mandatory testing to eliminate pervasive illnesses from herds. Veterinarians can rapidly and accurately identify Persistently Infected (PI) animal's on-farm, and immediately remove them to prevent virus spread and re-infection. AltraTech is developing a single-use portable semiconductor test kit for point of care testing of infectious viral diseases. The objective is to decentralise clinical blood testing into 'in the field' point of care settings, enabling rapid diagnosis and decision-making on site.

Challenges

To test and identify DNA/RNA, the protocols are only available in a laboratory environment and are both expensive and time consuming. Altratech developed a breakthrough sensor that could identify target DNA/RNA. To bring this innovative product to market they needed sensor interface circuits that would interrogate and read the novel sensor material. A dedicated Application Specific Integrated Circuit (ASIC) was required which integrated the sensor interface circuits and a high precision capacitive to digital converter, with a sensor array.

Benefits of Collaboration

AltraTech worked with MCCI under an Enterprise Ireland Innovation Partnership, which enabled them to leverage the knowledge and experience available in MCCI, to develop a custom ASIC which met the requirements of their unique application. Specifically it allowed AltraTech to leverage the experience of capacitive sensors and capacitive to digital converters within the MCCI team. The collaboration with MCCI has enabled Altratech to raise further, significant VC funding to bring this breakthrough innovation to market.

Research Outcomes

A key innovative element of this platform technology is an ASIC with integrated sensor array. AltraTech worked with MCCI to define the application requirements. An ASIC is required, since a solution based on individual discrete components would not be able to achieve the precision the application required. Secondly, a dedicated ASIC would enable additional new end applications, as well as enabling rapid in-field testing. The primary goal is to enable in-field testing of the resultant solution.

AltraTech

"The research team at MCCI worked with us to make our research idea a reality. We can now work to bring our innovation to market".

Tim Cummins, CEO, AltraTech.

The objective of this research collaboration was to decentralise clinical blood testing into 'in the field' point-of-care settings. This was achieved and enables rapid diagnosis and decision-making".

Donnacha O'Riordan, MCCI, Executive Director.

CUSTOM CHIP DESIGN GENERATION

Overview

Boston Scientific develop solutions for patients suffering from debilitating and life threatening conditions and the healthcare professionals who provide their care. The product innovations they develop enable healthcare providers to deliver effective healthcare by reducing costs and increasing efficiencies. Since the company was founded, it has advanced the practice of less-invasive medicine by providing a broad portfolio of products, technologies and services across a wide range of medical specialties.

Challenges

Implantable electronic devices require very low-power electronics to observe and stimulate the tissue or bio-interface, and these can take years to design and validate. An ubiquitous feature of high-value implantable medical devices is highly customised Application Specific Integrated Circuits (ASIC) which target a specific therapy. The opportunity with this collaboration was to create a versatile implantable microcircuit element to solve the generalised problem of the bio-electronic interface, and to enable the development of novel biomedical therapies.

Benefits of Collaboration

Boston Scientific's engagement with MCCI and delivery of the IC will enable the development of next generation therapies using implantable devices. The Innovation Partnership has validated the company's vision to build this microelectronics R&D capability in Clonmel. This is in part due to the proximity of the research expertise MCCI can provide.

Research Outcomes

The bio-interface chip that was developed by the MCCI team will make future systems simpler to design and create opportunities for novel biomedical therapies. The team develo an ultra-low power, custom ASIC that contains all the sense channels and stimulation circuitry required, and fits within a 10-year battery lifetime window. The IC includes stimulation, power management, multiple sense channels for therapy monitoring, and a flexible microprocessor interface to make the chip smarter, more sensitive and more power efficient.

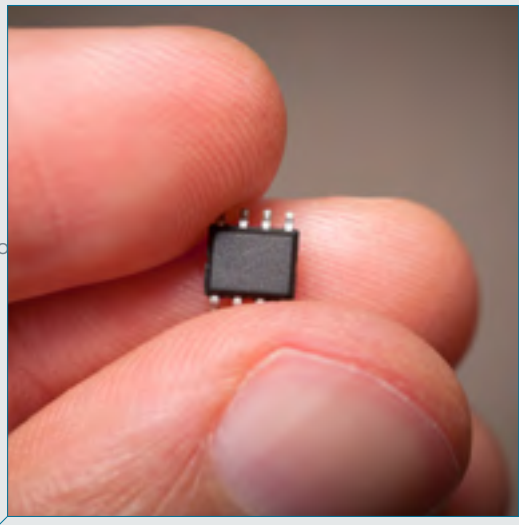
Boston Scientific

"The biomedical circuit research capability in MCCI is now a critical part of securing and growing Boston Scientific's R&D presence in Ireland."

Michael Keane, Process Development Director, Boston Scientific, Clonmel.

"We have combined the pacemaker and other novel circuits into a single chip in order to make them smarter, more sensitive and more power-efficient, in addition to reducing form factor."

Donnacha O'Riordan, MCCI, Executive Director.



IC DESIGN FOR SILICON PHOTOMULTIPLIER APPLICATIONS

Overview

SensL are the market leaders for extremely low light sensing applications. They have established themselves as an industry leader in the area of Silicon Photomultiplier (SiPM) sensors which rely on the Geiger mode photodiode for operation. SensL also have sensors deployed in Biophotonics, Hazard & Threat Detection and LiDAR (Light Detection And Ranging) products, which are used by companies looking to introduce autonomous vehicles.

Challenges

There is an ongoing drive for increased levels of integration in the areas of microelectronics and SensL are encountering demands from customers to address this issue. Increasingly, they must integrate their sensor with CMOS logic and develop an IP Library that is compatible with the developed process.

Benefits of Collaboration

SensL worked with MCCI under an Enterprise Ireland Innovation Partnership, which enabled them to validate how Analogue Mixed Signal designs would perform in this custom CMOS/ sensor process. SensL was able to leverage the existing design infrastructure that exists within MCCI, avoiding the immediate requirement to duplicate that in-house.

Research Outcomes

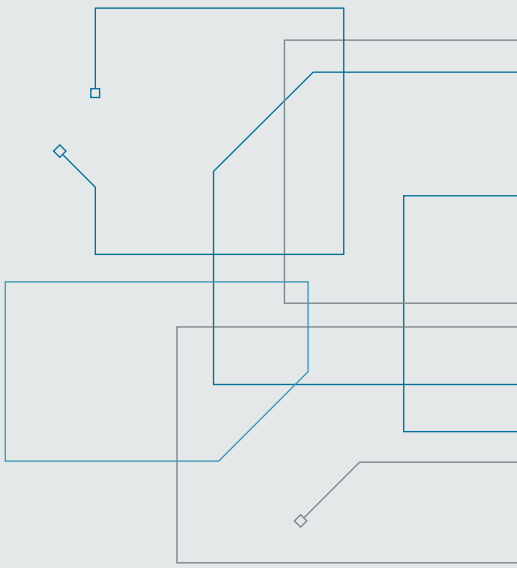
The development of a custom IP Library to complement SensL's CMOS/sensor process creates a significant opportunity for them. Firstly, it will enable SensL to support higher levels of integration, thereby reducing the cost of production. Secondly, a custom IP Library of building blocks which optimise the achievable performance by SensL's SiPM sensors enables additional market opportunities. Finally, this research will provide SensL with the capability to develop new features for future sensor-based products. This research project enabled continued growth within SensL, in terms of increased revenue, increased margins and profit.

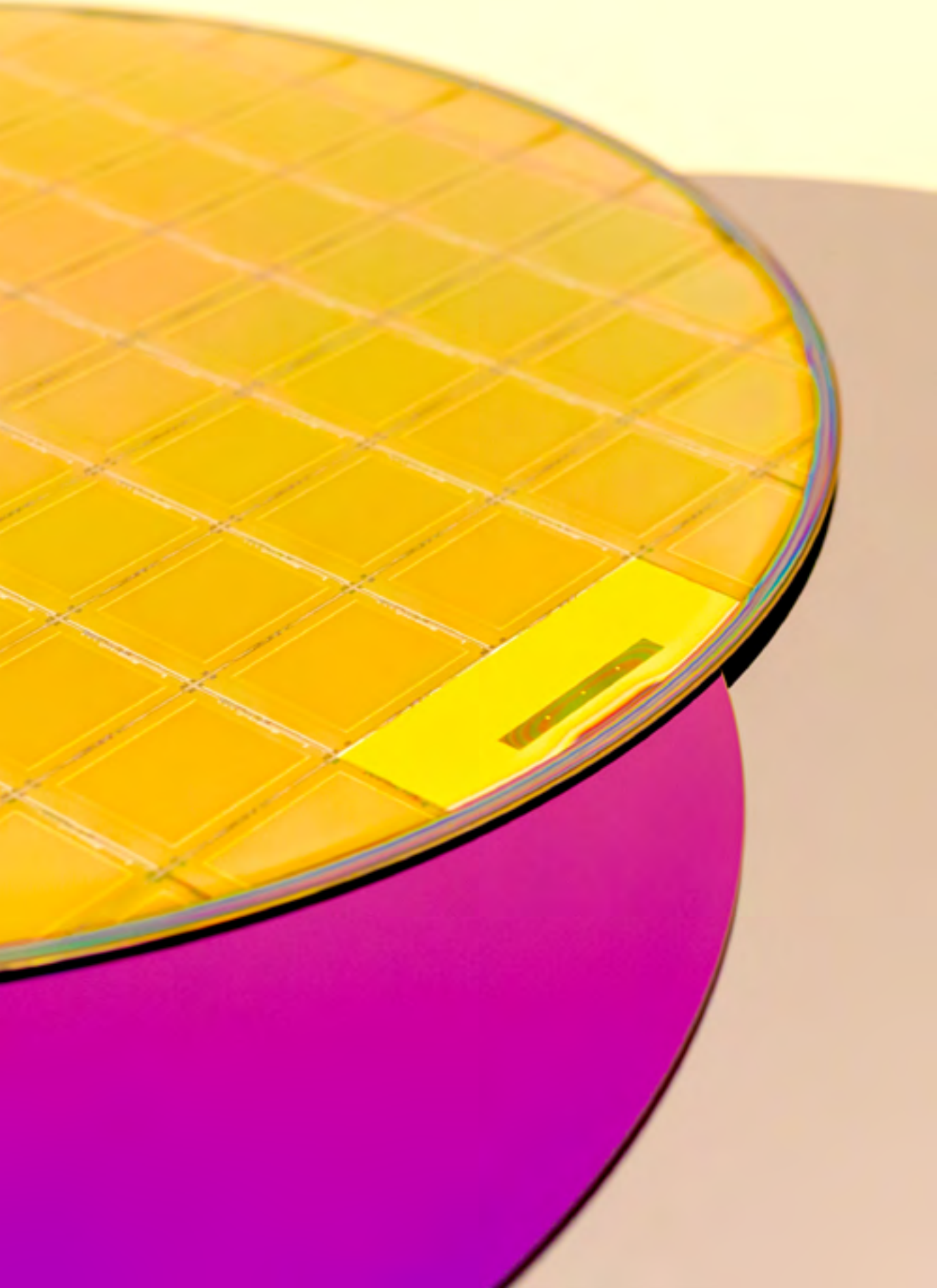
"We were pleased with the level of access to tools we got during the collaboration we had with MCCI."

Carl Jackson, CEO SensL

We were pleased that this collaboration enabled SensL to leverage the knowledge and experience available within MCCI to collaborate in the development of a custom Analogue Mixed Signal IP library, which will add significant value to their planned CMOS/sensor process."

Donnacha O'Riordan, MCCI, Executive Director.





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