

# Short-Course on Selected Topics in Mixed-Signal IC Design

By **Boris Murmann**

**Date:** 7<sup>th</sup> & 8<sup>th</sup> September, 2017

**Venue:** University of Limerick, Ireland



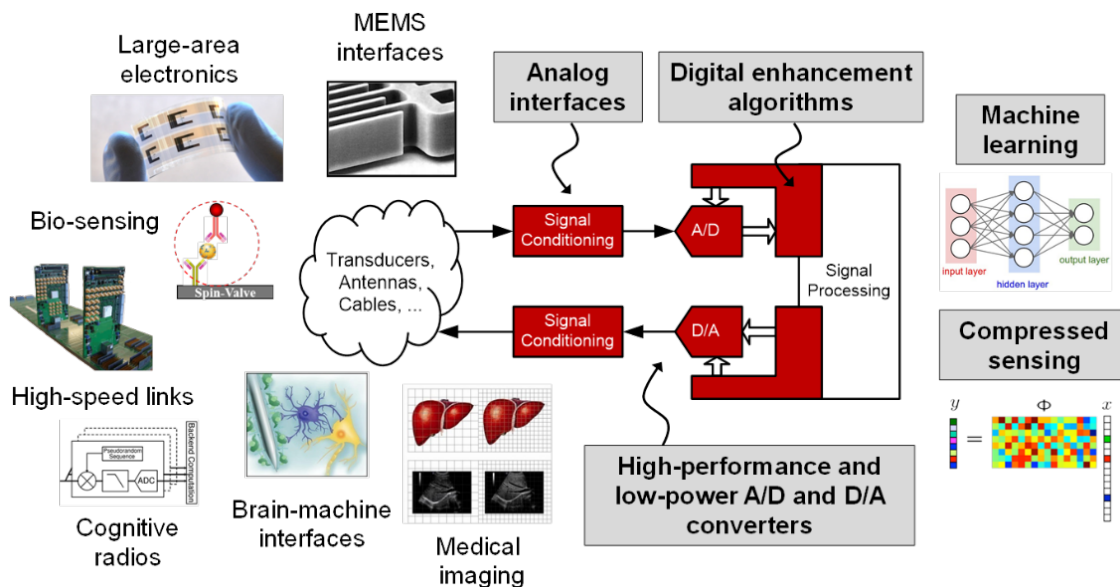
**UNIVERSITY of LIMERICK**

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While the 2015 & 2016 courses covered data conversion, this year's course will shift the attention toward modern sensor interfaces. It will cover the design of the constituent CMOS mixed-signal circuits, spanning a broad range of topics from "electrons to transistors, bits and algorithms." The overall objective is to deepen the attendees' understanding of sensor interfaces and their efficient translation into transistor-level circuits.

The first day begins with an overview that identifies modern driver applications, along with typical interface design approaches and associated circuit challenges. Throughout this course, the considered applications include MEMS/inertial sensing and a variety of examples from the biomedical space. This introduction is followed by a design-centric evaluation of CMOS technology, using the  $g_m/I_D$  ratio as the core variable. The understanding from the  $g_m/I_D$ -based characterization is then used to translate block specifications into transistor sizes in a systematic and re-use friendly manner. The considered blocks are typical interface gain and filter blocks and include switched-capacitor stages. This material on  $g_m/I_D$ -based design is a more detailed treatment of the introduction given in 2015.

The second day focuses on higher-level concepts and begins with a system-centric exploration of common interface solutions. Focus is placed on architectural options that enhance front-end sensitivity and selectivity based on application understanding. This material will also review widely-used techniques such as chopping and correlated double-sampling. The final two lectures zoom out further and look at the interface in terms of the processed information. This leads to an introductory discussion of compressed sensing and machine learning (inference) techniques, which are currently being considered in advanced research.



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## Course Programme

### Thursday, 7th September, 2017

- 08:30-09:00 Registration & Welcoming
- 09:00-10:30 Lecture #1 – Anatomy of mixed-signal interfaces: Driver applications, design approaches & circuit requirements
- 10:30-11:00 Coffee Break
- 11:00-12:30 Lecture #2 – Benchmarking the CMOS fabric: Transconductance, noise, distortion, mismatch
- 12:30-13:30 Lunch Break
- 13:30-14:00 [Guest Lecture \(Prof. Coffey\): "Robotic Surgery: Past, Present & Future"](#)
- 14:00-15:30 Lecture #3 – Systematic design of gain stages (Part I)
- 15:30 -16:00 Coffee Break
- 16:00-17:30 Lecture #4 – Systematic design of gain stages (Part II)

### Friday, 8th September, 2017

- 09:00-10:30 Lecture #5 – System-driven sensor interface design (Part I)
- 10:30-11:00 Coffee Break
- 11:00-12:30 Lecture #6 – System-driven sensor interface design (Part II)
- 12:30-13:30 Lunch Break
- 13:30-14:00 [Guest Lecture \(Tim Cummins\): "Semiconductors in BioTech"](#)
- 14:00-15:30 Lecture #7: Introduction to compressed sensing techniques
- 15:30 -16:00 Coffee Break
- 16:00-17:30 Lecture #8: Introduction to machine learning and inference

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### **Biography**

Boris Murmann is a Professor of Electrical Engineering at Stanford University. He joined Stanford in 2004 after completing his Ph.D. degree in electrical engineering at the University of California, Berkeley in 2003. From 1994 to 1997, he was with Neutron Microelectronics, Germany, where he developed low-power and smart-power ASICs in automotive CMOS technology. Since 2004, he has worked as a consultant with numerous Silicon Valley companies.

Dr. Murmann's research interests are in mixed-signal integrated circuit design, with special emphasis on sensor interfaces, data converters and custom circuits for statistical inference. In 2008, he was a co-recipient of the Best Student Paper Award at the VLSI Circuits Symposium and a recipient of the Best Invited Paper Award at the IEEE Custom Integrated Circuits Conference (CICC). He received the Agilent Early Career Professor Award in 2009 and the Friedrich Wilhelm Bessel Research Award in 2012. He has served as an Associate Editor of the IEEE Journal of Solid-State Circuits, as well as the Data Converter Subcommittee Chair and the Technical Program Chair of the IEEE International Solid-State Circuits Conference (ISSCC). He is a Fellow of the IEEE.

He has authored/co-authored over 150 publications, including 4 books and 5 book chapters.

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### Biography

Professor J. Calvin Coffey is the Foundation Chair and Professor of Surgery at the Graduate Entry Medical School, University of Limerick and a consultant general and colorectal surgeon at the University Hospital Limerick Group, Limerick. He qualified with a first class honours B.Sc. in Anatomy in 1995, under the supervision of Professor Kieran McDermott, in University College Cork. He qualified in Medicine in 1998 from University College Cork. He obtained a PhD in Surgery in 2006 and completed surgical training in 2010 at the Cleveland Clinic, Ohio, USA. He took up his current post in 2010 and is also Deputy Director of the 4i Centre for Interventions in Infection, Inflammation and Immunity.

His primary clinical interests are open, minimally invasive and robotic intestinal surgery. He has performed several thousand intestinal resections. He pioneered robotic intestinal surgery in Ireland and his group have received numerous clinical awards including the Healthcare Development Initiative/ Large Teaching Hospital award at the Irish Healthcare Centre Awards, 2017, in recognition of development of robotic intestinal surgery in Ireland. He was invited to present the Distinguished Alumnus Lecture at the Cleveland clinic in 2012. He was awarded the prestigious James the IV International Surgical Fellowship and has been the recipient of numerous named national and international lectures. These include the Millin Lecture, The Sir Thomas Myles Lecture, and the Robert Smith Lecture at the Annual Congress of The Association of Surgeons of Great Britain and Ireland.

His primary research interests relate to the emerging field of mesenteric science. His research group has published several hundred research papers, and been awarded numerous national and international awards including the William O Keefe Prize, The Freyer Prize, The ASGBI Best Paper Prize. He is chief author of the book entitled *Mesenteric Principles of Gastrointestinal Surgery: Basic and applied Sciences*, and Editor in Chief of the recently established journal "Mesentery and Peritoneum (MAP)." He has published in *Nature Reviews*, *The Lancet Gastroenterology and Hepatology* on the importance of anatomy in standardising intestinal surgery. His article, "The Mesentery; structure, function and role in disease" reached an Altmetric score of 2020. He has developed numerous novel surgical techniques, based on anatomy, in the surgical management of acquired and congenital abnormalities of the intestine and mesentery.

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## Biography

- Tim Cummins
- CTO & co-founder, AltraTech Ltd, Limerick – Semiconductor Biotechnology
- MD & Product Line Director, Silicon Laboratories Irl Ltd – 2010 – 2013
- Founder & CEO at ChipSensors - acquired by Silicon Labs
- Founder & Managing Director, Cratlon Ltd, IC design consultancy team, €1M revenue
- Mixed-signal IC Designer, Design & Technology Manager at Analog Devices
- Sensor Electronics designer at Westinghouse
- Inventor - 18 US patents, generating > \$100M revenue in Semiconductors & Sensors
- Senior Member IEEE; 5 published papers (incl ISSCC, ESSCIRC); 2 JSSCC journal papers
- Visiting lecturer University of Limerick, EE6641 Semiconductor Technology