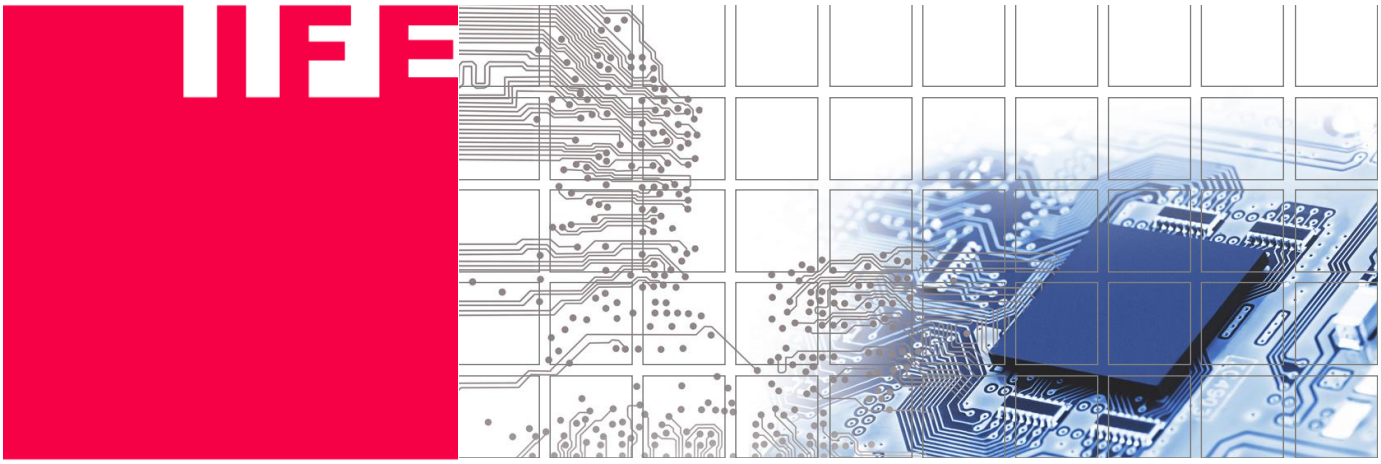
Institut für Elektronik



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Selected Topics of Advanced Analog Chip Design

Winter semester 2021/2022

Lecture contents of this semester:

Memory design, millimeter wave wireless sensing, agile analog design, time of flight 3D design, depth sensing, circuit layout and design methodology, Berkeley Analog Generator,...

Location: HS i4 / HS i6 / Online: WebEx Meeting

Course dates:

Date	From	To	Place	Lecturer	Topic
26.11.2021	12:00	14:00	Online / Webex	Johannes Fellner	Memory Design for Integrated Circuits
03.12.2021	12:00	14:00	Online / Webex	Brian Ginsburg	mm-Wave Imaging for Automotive and Beyond
10.12.2021	12:00	14:00	HS i4 (Online / Webex)	Timuçin Karaca	I-TOF 3D Imaging
14.01.2022	12:00	14:00	HS i6 (Online / Webex)	Ion Vornicu	Depth sensing solutions: design challenges from device to system integration
21.01.2022	12:00	14:00	HS i6 (Online / Webex)	Mirjana Videnovic Misic, Fatemeh Abbassi	Circuit Layout and Design Methodology using the Berkeley Analog Generator (BAG) Framework
28.01.2022	09:30	11:30	HS i (to be defined) (Online / Webex)	Bernhard Wicht	Power Management and DC-DC Converters – An Introduction to Circuits and Systems
28.01.2022	12:00	14:00	Online / Webex	Rafael Ballabriga	Hybrid Pixel Detector design for research and industrial applications

List of Abstracts:

Memory Design for Integrated Circuits

Johannes Fellner, ams OSRAM, Premstätten, Austria

Memories in integrated circuits are fundamental IPs and especially needed in the context of digital designs. The first part of this presentation is giving an overview for all different types of memory and the different bit cell concepts of volatile memories like Static RAMs and non-volatile memories like ROMs, One Time Programmable (OTP) Memories and EEPROM/Flash concepts. The second part is focussing on industry standard design techniques and comparator circuits for volatile and von-volatile memories, and will address the challenges for memory design and qualification. Presenting lifetime investigations and cross sections on OTP memories, but also the different aspects on multi programmable memories based on different technologies.

Johannes Fellner has received his M.SC. degree from Graz University of Technology as technical physicist. His master thesis on the topic “Noise in Transistors” was already done in cooperation with AustriaMicrosystems (ams) in 1996 and after his promotion he joined ams as employee. The technical career path was strongly linked to One Time Programmable Memories, from characterization and qualification up to the optimization and designing of memory bit cells. Today he is leading the corporate design department at ams OSRAM supporting Memories but also other key Analog Design IPs.

mm-Wave Imaging for Automotive and Beyond

Brian Ginsburg, Texas Instruments, Dallas Texas, USA

Millimeter wave frequency operation offers wide bandwidths, precise localization, and rich material interaction and penetration capability. Meeting consumer demand for enhanced safety, 77GHz automotive radar is one of the fastest growing features in automotive. Leveraging the dense integration and fast transistor performance of modern silicon processes, emerging MMICs are delivering higher performance in a smaller form factor and are also extending the mm-wave capabilities to other sensing markets, including intelligent infrastructure, robotic navigation, high accuracy displacement and motion sensing, and human interaction. This talk will cover these application trends and how they are enabled by emerging radar ICs.

Brian Ginsburg received his S.B., M.Eng., and Ph.D. degrees from the Massachusetts Institute of Technology. He joined Texas Instruments, Dallas, Texas in 2007 working in its wireless terminals business unit and TI’s Kilby Labs. Now, he is a Distinguished Member of Technical Staff and the systems manager of TI’s radar business. He has served on the technical program committee for the International Solid-State Circuits Symposium and is the Symposium Co-Chair of the 2021 Symposium on VLSI Circuits.

I-TOF 3D Imaging

Timuçin Karaca, Infineon Technologies Austria AG, Graz, Austria

Indirect Time of Flight 3D imaging is an emerging technology used in 3D cameras. The technology is based on measuring the time of flight of modulated light. It allows to generate fine grain depth images with several hundreds of thousand image points. I-TOF has become a standard solution for face recognition and authentication. Recently I-TOF is also used in various new applications, such as computational photography, gesture recognition and robotics. This talk will introduce the basic operation principle of an I-TOF 3D imager IC. The integrated building blocks will be discussed and the analog operation of an I-TOF pixel will be addressed in detail. System level topics of the camera module will also be covered to provide a complete overview of the technology.

Timuçin Karaca has received his M.SC. degree from Graz University of Technology. In 2018 he finished a Ph.D. on the design of Class-D audio amplifiers with special focus on electromagnetic compatibility. His background is mainly analog and mixed signal circuit design. In his previous positions he has been working with NXP Semiconductors and ams. He is currently with Infineon Technologies as a concept engineer for optical imaging and ranging detectors.

Depth sensing solutions: design challenges from device to system integration

Ion Vornicu, Silicon Austria Labs GmbH, Linz, Austria

Depth sensing has always been a very dynamic multidisciplinary research field, enabling a variety of applications such as transportation, robotics, consumer, topography, space, and medical imaging. Based on the last decade's technological advances, light detection and ranging (LiDAR) is expected to be a game-changer in the autonomous driving market. Time-of-flight (ToF) is also a powerful technique enabling new capabilities in medical imaging.
In this talk, we will take a deep dive into depth-sensing technologies to understand the challenges from device engineering to system integration. The focus is on the ToF for both light and ultrasonic detection and ranging solutions. Moreover, ToF is compared to the frequency modulated continuous wave (FMCW) approach.
From the system level perspective, some representative application scenarios involving distance ranging and 3D imaging are discussed. Besides, the involved principles, waveband, and metrics are introduced. Next, the sensing devices are addressed, such as single-photon avalanche-diodes (SPADs), silicon photomultipliers (SiPMs), and piezoelectric micromachined ultrasonic transducers (pMUTs). The design parameters and their impact on the overall performance of the system are analyzed. Moreover, the technological challenges involved by the application-driven system-level requirements are also discussed. This leads to the next part of the talk dedicated to the optical path in the depth-ranging systems. The emphasis is on beamforming and beam steering techniques. The impact of Si photonics on the next generation of LiDAR is also tackled. Next, the focus of the

presentation will change on the main building blocks with particular emphasis on time-to-digital converters (TDC) for direct ToF measurements. The last topic addresses data processing requirements for high-performance LiDAR systems.
This talk is concluded with the identification of some application-driven research directions and their challenges towards monolithically integrated depth-sensing systems.

Ion Vornicu received the B.Sc. in Electronic Engineering (Microtechnologies), M.Sc. in Modern Signal Processing Techniques, and Ph.D. in Microelectronics, all of them from the Technical University of Iasi, Romania, in June 2008, July 2009, and December 2011.
From Dec. 2011 to May 2021, he was an Associate Researcher at the Institute of Microelectronics of Seville (IMSE), a joint CSIC-University of Seville center. He pursued a new line of research at IMSE, i.e., CMOS image sensors (CIS) based on single-photon avalanche-diodes (SPADs) for photon counting and time-of-flight (ToF) applications. He developed several demonstrators with the SPAD imagers that he had designed for positron emission tomography (PET) and 3D imaging. He was the technical lead on LiDAR development and one of the promoters of Photonvis S.L., a spinoff company of the University of Seville, Spain.
Since June 2021, he is a Senior Scientist for Analog and Mixed-Signal Integrated Circuit Design at Silicon Austria Labs GmbH (SAL) in the RF Systems, Frontend Integrated Circuits, and Systems research group.
He has authored and co-authored 35 scientific publications, of which 14 are SJR articles. He co-authored a book chapter and holds 2 patents. He received the best paper award from the Sensory System Technical Committee at International Symposium on Circuits and Systems 2016. He peer-reviewed over 70 manuscripts at different journals and international conferences.
His main areas of interest are the modeling, design, and test of ToF-CIS based on SPADs for 3D imaging and LiDAR, digital silicon photomultipliers (dSiPMs) for medical applications, and low noise analog mixed-signal integrated front-end for ultrasonic transducers, MEMS micro-mirrors, and micro-bolometers. At the circuit level, he focuses on the design of SPAD devices, SPAD pixels, SPAD-CIS architectures, pulsed laser drivers, amplifiers, phase-locked loops (PLL), delay-locked loops (DLL), time-to-digital converter (TDC), oscillators, low noise amplifier (LNA), programmable gain amplifier (PGA), analog-to-digital converters (ADC), DC-DC boost converters, high-voltage pulsers, and FPGA design.

Circuit Layout and Design Methodology using the Berkeley Analog Generator (BAG) Framework

Mirjana Videnović-Mišić, Fatemeh Abbassi, Silicon Austria Labs GmbH, Linz, Austria

In a time when the complexity of analog designs is constantly increasing, how to be agile? In this talk we will present a couple of examples related to the circuit design methodology and layout developed in Berkeley Analog Generator 2 (BAG2) framework. The idea is to show initial steps/procedures needed to speed up the design development cycle beyond analog flow automation. Examples with address two main domains: gmoverid methodology implementation and layout generation (initial methods, applying layout techniques) towards circuit reuse and technology portability. Finally, the taped-out two stage operational amplifier and its measurement results will be presented.

Mirjana Videnović-Mišić received the M.Sc. and PhD degree in Electronics and Microelectronics engineering from the University of Novi Sad, Serbia, in 2004 and 2009 respectively. In 2009 she founded the Team for analog and radio frequency integrated circuit design (ICreate) at the University of Novi Sad, Serbia. In 2010 she joined Faculty of Technical Sciences, University of Novi Sad as an assistant professor covering the topics from semiconductor modeling to analog and radio-frequency integrated circuit design. In 2014/2015 she was Fulbright Visiting Scholar and from 2015-2018 she was the Marie Currie Individual Global Fellowship recipient. Both fellowships were executed in cooperation with the Berkeley Wireless Research Center, University California at Berkeley. Her research interests include the analysis, design and optimization of the analog and radio frequency integrated circuits for 5G and beyond 5G applications.

Fatemeh Abbassi received the B.Sc. degree in electrical engineering from the K.N. Toosi University of Technology, Tehran, Iran, in 2011 and the M.Sc. degree in electrical engineering (Microelectronics) from the Sharif University of Technology, Tehran, Iran, in 2013. From 2017 to 2019, she was working as a research assistant in the School of Information and Communication Engineering at the IC Lab, Sungkyunkwan University, Suwon, Korea. In 2019, she joined Silicon Austria Labs (SAL), Linz, Austria and is currently pursuing the Ph.D. degree in collaboration with the Institute for Integrated Circuits, Johannes Kepler University, Linz, Austria. Her research interests include analog and radio frequency circuits with a special focus on RF receiver front ends using Analog Generator.

Power Management and DC-DC Converters – An Introduction to Circuits and Systems

Bernhard Wicht, Institut für Mikroelektronische Systeme, Leibniz Universität Hannover, Germany

Power management comprises integrated circuits for highly efficient power supplies and for controlling power switches. These have recently gained tremendous importance in order to make electronic solutions for global growth areas such as renewable energies, autonomous driving and IoT more compact, more energy-efficient and more reliable. Future applications in the field of machine learning and AI will only be possible with intelligent power management to supply complex processors and sensors. The first part of this lecture gives an overview at system and circuit level of current and future challenges, along with examples including the topics of automotive, wearables and GaN. System behavior and performance of power management strongly depend on the implementation on circuit level. The second part of this talk covers the design of DC-DC converter building blocks like power switches, gate drivers and their supply, level shifters, error amplifier as well as control loop and current sensing techniques. The lecture will highlight various design trade-offs related to speed, efficiency, complexity, voltage and current capabilities.

Bernhard Wicht has 20+ years of experience in analog and power management IC design. He received the Dipl.-Ing. degree in electrical engineering from University of Technology Dresden, Germany, in 1996 and the Ph.D. degree (Summa Cum Laude) from University of Technology Munich, Germany, in 2002. Between 2003 and 2010, he was with Texas Instruments, Freising, responsible for the design of automotive power management ICs. In 2010, he became a full professor for integrated circuit design and a member of the Robert Bosch Center for Power Electronics at Reutlingen University, Germany. Since 2017, he has been heading the Chair for Mixed-Signal IC Design at Leibniz University Hannover, Germany. His research interest includes IC design with focus on power management, gate drivers and high-voltage ICs. Dr. Wicht was co-recipient of the 2015 ESSCIRC Best Paper Award and of the 2019 First Prize Paper Award of the IEEE Journal of Emerging and Selected Topics in Power Electronics. In 2018, he received the faculty award for excellent teaching at his university. He invented seventeen patents with several more pending. He is currently a member of the Technical Program Committee of ISSCC and he is also a Distinguished Lecturer of the IEEE Solid-State Circuits Society.

Hybrid Pixel Detector design for research and industrial applications

Rafael Ballabriga, CERN microelectronics group, Geneva, Switzerland

This talk will describe hybrid pixel detector technologies that are used to detect radiation in medical and scientific instruments. The talk will review the sensor materials that are used and their non idealities, then we will focus on the readout electronics. A review of ASICs will be presented and finally, we will speak about applications of the technology in medicine and industrial.

Rafael Ballabriga is a graduate of the Ramon Llull University in Barcelona (BSc 2000, MSc 2002). In 2004, he joined CERN microelectronics group, Geneva (Switzerland), in the framework of the CERN Doctoral Student Program to work in the design and characterization of hybrid pixel detectors. Rafael Ballabriga received the IEEE NPSS Best Student Paper Award in 2006. He defended his PhD thesis entitled “The Design and Implementation in 0.13um CMOS of an Algorithm Permitting Spectroscopic Imaging with High Spatial Resolution for Hybrid Pixel Detectors” in 2009 for which he received the best thesis award of the Ramon Llull university doctoral programme 2009-2010. In 2013 he received the IEEE Nuclear and Plasma Sciences Society Radiation Instrumentation Early Career Award. Rafael Ballabriga has coached younger designers in the design of front-ends in CMOS technologies. Holds three patents and has authored or co-authored more than 70 peer-reviewed journal publications.

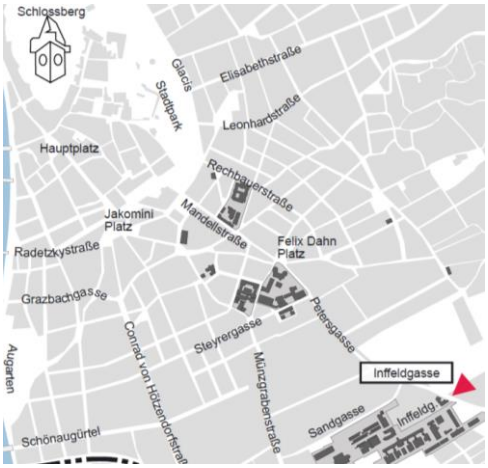
How to participate:

Webex Meeting:

Meeting link: https://tugraz.webex.com/meet/bernd.deutschmann

Directions/How to reach us:

HSi4 /HSi4 → TU Graz, Inffeldgasse 25D



I look forward to welcoming you to the lectures.

With kind regards,

Bernd Deutschmann

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