SKL-AMSV Innovation Centers

Wireless and Multidisciplinary Innovation Center (WMIC)

To develop circuit techniques devoted to practical problems, to invent new concept-to-solution designs to underpin the development of wireless industry, and to develop advanced micro/hybrid systems that can be applicable to human beings, with research in biology and chemistry. Several key directions are highlighted:

- Ultra-low-power ZigBee and Bluetooth Low Energy (BLE) radios for low-power low-cost wireless connectivity such as Internet of Things.
- Wideband flexible receivers and transmitters for 5G communications.
- Micro-power analog circuits with enhanced performances, power and area efficiencies.
- Electronics-automated digital microfluidics with software-defined intelligence.
- Portable nuclear magnetic resonance (NMR) electronics for precision medicine.
- Ultra-low-power solar-powered CMOS/beyond-CMOS sensing chips.

Wireless IC

This research line focuses on RF and mmWave ICs for a wide variety of applications, including but not limited to, 3G/4G/5G multi-standard cellular radios, ultra-low-cost ultra-low-power IoT radios, and tens-of-MHz radios for micro-nuclear magnetic resonance (μNMR) applications. The key research interests are:

- Sub-6GHz 2G/3G/4G wireless transceiver front-ends, and >28GHz 5G transceiver front-ends. SAW-less RF-flexible receivers and transmitters using our proposed gain-boosted N-path filter techniques are investigated.
- Ultra-low-power IoT transceiver front-ends from sub-GHz to 2.4GHz, conforming to Bluetooth Low Energy (BLE), ZigBee and NB-IoT. Ultra-low-cost and ultra-low-power RF and baseband (BB) techniques using our proposed function-reuse gain-boosted N-path receiver, RF-to-BB-current-reuse receiver, function-reuse VCO-PA, and ultra-low-voltage receiver, transmitter and frequency synthesizer using a local micro-power manager are investigated.
- Analog baseband circuits such as micro-power amplifiers with high capacitive load drivability, continuous-time/discrete-time filters with a very compact chip area, energy-harvesting units with high efficiency, sensor readout interfaces with low noise effective factor, and crystal oscillators with low startup energy are investigated.
- RF/mmWave circuits such as active-inductor-enhanced wideband amplifiers, multi-harmonic-peaking wave-shaping VCOs, time-interleaved ring oscillators with a wide tuning range, and type-I phased-locked loops with ultra-low-voltage operation are investigated.
- Digital baseband correction techniques for I/Q mismatch, LO feedthrough and strong-memory-effect distortion in wideband transmitters are investigated.
- Tens-of-MHZ (e.g., 20MHz) transceivers with a sensing coil (on/off-chip spiral inductor) to allow electronic-automated biological and chemical assays in a small form factor.

The invented techniques are expected to advance the state-of-the-art knowledge in the fields, and should be potentially transferrable to the industry for practical applications.

Biomedical IC

The research line focuses on advanced micro/hybrid systems that can be applicable to human beings, biological and chemistry researches. The key research interests are:

- Advanced electronics platform for small animal behavioral study. Miniaturized circuit/SoC for simultaneous extracellular electrophysiology recording and optogenetic neural manipulation is studied.

- Micro ultrasound transducer for biological imaging and measurement. New membrane structure CMUT is designed and fabricated based on MEMS technology to enhance the output ultrasonic pressure. Multi-frequency CMUT is investigated to extend the imaging capability of photoacoustic imaging.

- Intra-body Communication with study in physical layer and MAC layer and their IC implementation.

- Microprocessor with built in multi-tasking ability for biomedical engineering applications. This can be used as a platform for ASIC development for related applications.

- Ultra-low-power energy harvesting CMOS biomedical implantable sensing chip. Single-chip energy harvesting solution with various ambient sources for low voltage operation, high efficiency and ultra-compact form factor are investigated.

- Ultra-low power biopotential interfacing circuit. Nanowatt analog signal processing and filtering is studied, focusing on nanowatt circuit design, subthreshold operation, linearity improvement and gain compensation.

- Digital microfluidic chips with software-defined intelligence. On-chip 3D structures for precise droplet splitting, fuzzy-logic and real-time feedback for precise droplet positioning, and non-DC driving voltage wave- forms for higher droplet moving speed are investigated.

  The invented techniques are expected to advance the state-of-the-art in terms of performances and understanding, and should be transferrable to the industry for practical applications.

Data and Power Conversion Innovation Center (DPIC)

The main objective of this center is to focus on innovative research and development of high-performance data conversion and signal processing analog front-ends ICs and integrated power ICs including:

- Analog-to-Digital Converters (ADCs)
- Video/ Audio Codecs
- Power converters
- Data conversion interface for wireless and wireline communication
- Signal processing analog frontends for sensors and autonomous systems
- High efficiency, wide input range, wide load current range, and fast response power management DC-DC converters, low dropout regulators, etc.

Data Conversion and Signal Processing

The main objective of the research line is focus on innovations on high-performance data conversion and signal processing analog ICs, including those covering the most emerging applications e.g. 4G LTE, LTE-A, Ultra Low Power IoT devices, wideband (wirelined- or optical communication), etc. The following lists the key research interests:

- Power efficient data converters for portable and autonomous IoT system. The projects are based on the dynamic based circuits, like inverters, comparators, successive approximation register (SAR), binary search ADC etc. to achieve very low power consumption data converter implementation.

- Digitally-assisted / calibrated high resolution CMOS data converters for high quality video, cellular and data acquisition front-ends. This projects study the innovation that relies on the advanced scaling nanometer CMOS technology that bring the strong processing power of digital circuits, to assist the detection and calibration of the various analog circuit non-idealities like offset/gain errors, nonlinearity, various mismatch among different channels, etc.

- Oversampling noise-shaped sigma-delta converter for wireless applications. This project concentrates on the innovation techniques improving the noise-shaping performance in the discrete-time and continuous-time sigma-modulator modulator.

- Ultra wide bandwidth data converters for optical communications. This project investigates different techniques to extend the bandwidth physical limits in the data converter. The possible direction includes the interleaving with calibration or compensation of various mismatches, and utilize the time-based converters to take advantages of technology scaling.

- Application of data converters in various electronics application including sensors, power converters and navigation systems. This project focused more on the application aspect of the data converters. Current projects include the design of sensing interface for power electronics converters, and an accelerometer/ velocity meter/position meter sensing analog sigma-delta front-end interface for navigation systems.

Integrated Power

The research directions are:

- Integrated power electronics controller design: The integrated power electronics controller can significantly improve the power electronics system performances and is easy to be implemented by others (without knowledge and save programming time) compared with conventional DSP controller. Moreover, the integrated power electronics controller is possible to replace the digital controller in the power compensator products. This research work focuses on programmable gain signal conditioning circuit, analog-to-digital (A/D) conversion, and pulse-width-modulation (PWM) generator. Up to now, there is no such three-phase power electronics controller IC in the market.

- Power management IC design: Fully-integrated high efficiency, wide input range, wide load current range, small output ripple, and fast transient response power management circuits, including inductor-based and switched-capacitor DC-DC converters, low dropout regulators, etc. are of great interest.

- Wireless power transfer: Wireless power transfer (WPT) has a wide range of applications including (arranged from low to high power levels) radio frequency identification (RFID), internet-of-things (IoT), implantable medical devices (IMDs), real-time wireless power for non-contact memory devices and wafer-level testing, and also wireless chargers for portable/wearable devices and electric vehicles (EVs). It is evident that the utilization of WPT technologies is on the critical point of exponential growth.

The research line aimed at the investigation of the advantages of using microelectronics through signal processing and intelligence in order to improve the performance of energy processing power electronics systems, which is related with software control and hardware IC implementation. Power management and wireless power transfer are our research focuses.

SKL-AMSV Innovation Centers

Microelectronics Research Center at Zhuhai UM S&T Research Institute (SKL-AMSV Hengqin Branch)

模拟与混合信号超大规模集成电路
国家重点实验室（横琴分部）

State Key Laboratory of
Analog and Mixed-Signal VLSI
(Hengqin Branch)

In response to the Development Plan Outlines for the Guangdong-Hong Kong-Macao Greater Bay Area, the Microelectronics Research Center (MRC) at Zhuhai UM S&T Research Institute (ZUMRI) was established in 2019, aiming at demonstrating a successful example of research technology commercialization in Zhuhai Hengqin, connecting Macau with the other cities in the Greater Bay Area. The Microelectronics Research Center operates as a Hengqin Branch of the State Key Laboratory of Analog and Mixed-Signal VLSI of the University of Macau (UM), providing one more platform and opportunity for UM microelectronics professors to conduct applied research and development. Also, Hengqin has a much larger area compared to Macau, attracting UM graduates to stay and helping UM professors to expand their research groups. With such, the Institute of Microelectronics at UM greatly boosts the number of graduate students, nurturing more skilled and talented engineers not only for Macau and Hengqin, but also for the whole IC industry of China.

The satellite Hengqin Branch serves as the following functions:

- Absorbing government funds and commercial projects in Mainland China.
- Providing more lab and office spaces for more UM graduate students.
- Recruiting post-doctoral researchers and research assistants for UM professors.
- Incubating startup companies of UM microelectronics professors.
- Organizing academic-industrial cooperation forums and technical workshops.
- Setting up an open integrated circuit testing laboratory for the region.

In 2020, UM professors attracted over 10 million CNY research funds, mostly from the industry, through the MRC at ZUMRI. As of Oct. 2021, there are about 10 UM professors undertaking more than 20 projects funded by the National Natural Science Foundation of China (NSFC), the Ministry of Science and Technology of China, Guangdong Province, Zhuhai City, and several Top China IC design companies. Currently, there are 3 post-doctoral researchers and 8 research assistants working in the “Phase-I” space, while the “Phase-II” space is expected to start operating with more manpower in early 2022.

In addition, the MRC helped UM and ZUMRI on co-organizing several influential technical forums and workshops in Mainland, including but not limited to the Workshop on IC Advances in China (ICAC), ISSCC China promotion and press conferences, considerably increased the reputation of UM and the SKL-AMSV in the Greater Bay Area and beyond.