SKL-AMSV Main Research Lines

Wireless IC

Prof. Pui-In Mak, Research Line Coordinator

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.

Data Conversion and Signal Processing

Prof. Sai-Weng Sin, Research Line Coordinator

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.

SKL-AMSV Associate Research Lines

Biomedical IC

Prof. Mang-I Vai, Research Line Co-Coordinator
Prof. Pui-In Mak, Research Line Co-Coordinator

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 waveforms 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.

Integrated Power

Prof. Man-Chung Wong, Research Line Co-Coordinator
Prof. Sai-Weng Sin, Research Line Co-Coordinator

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.