2· 項目簡介

(*項目所屬科學技術領域、主要技術內容、授權專利情況、技術經濟指標及應用推廣情況*)

The ubiquitous sensing and control capability over a vast number of objects provided by the ever-expanding network infrastructure of Internet-of-everything (IoE) significantly facilitate our daily life and increase productivity. To keep trillions of devices always online efficiently, advanced electronic chips are urgently demanded. Besides the low-power and low-cost requirements, these chips are also expected to be self-powered to alleviate the battery replacement effort. Moreover, the off-chip components should be avoided to enable a tiny device that can be flexibly deployed.

This project focuses on the key technologies for the energy-autonomous wireless/wireline chips that enable Internet-of-everything (IoE) connectivity. The major technological breakthroughs of this project, developed by the team from the State-Key Laboratory of Analog and Mixed-Signal VLSI of the University of Macau, are summarized in the following three parts.

1) Wireless and wireline data receiving and transmitting: Targeting for eliminating the off-chip components and addressing the battery replacement challenge, we invented advanced N-path filtering techniques to realize multi-band receiver and transmitter for 5G New Radio without the need for bulky external surface-acoustic-wave (SAW) filters. Also, we developed low-power Bluetooth Low-Energy (BLE) receiver and transmitter that can achieve excellent power efficiencies when operating at an ultra-low supply voltage of 0.2V generated by the energy-harvesting sources.

2) Environmental energy harvesting: The voltages generated by different energy harvesters vary a lot under different environmental circumstances, which demands the high-efficient power management circuit with programmable voltage conversion ratios (VCRs). To address this challenge, we proposed an algorithmic voltage-feed-in (AVFI) switched-capacitor power converter (SCPC) topology capable of systematic generation of any arbitrary buck-boost rational ratio with high conversion efficiencies. We also invented a fully-integrated piezoelectric energy harvesting interface to eliminate the off-chip inductor and provide a programmable VCRs.

3) Clock and frequency generation: Every IoE chip would require multiple clock and local oscillator (LO) signals for signal processing and digitizing and signal receiving and transmitting. To generate precious clock and LO signals efficiently, we proposed various innovative circuit and system architectures to improve the phase noise, spur, power and area efficiencies of the phase-locked loop (PLL) and oscillator from radio frequency (RF) to millimeter-wave (mm-Wave) frequency.

The techniques developed from this project was academically transferred via 25 IEEE journals (including 9 in the prestigious IEEE Journal of Solid-State Circuits), and 5 papers in the IEEE International Solid-State Circuits Conf. (ISSCC), maintaining the leading position for our group in the top research groups from MIT, Stanford University and Tsinghua University during the same period. In addition, this project trained a number of highly-caliber PhD students. Three of them won the IEEE Solid-State Circuits Society (SSCS) Pre-Doctoral Achievement Award. Besides, we are conducting or negotiating collaboration projects with several IC companies, including Huawei Hisilicon, to transfer the knowledge from this project to the IC industry.

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