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*)
To build a smart city, low-power internet-of-things (IoT) hardware is the backbone of the smart system. It is widely believed that the ever-expanding network infrastructure of IoT enables ubiquitous sensing and control capability over a vast number of interested objects, with the applications for smart home, remote healthcare, smart buildings, intelligent transportation, etc. Therefore, the demand for high performance ICs (chips) is not saturating but non-stop fast growing. However, China, as the world's largest IC consumer, still heavily relies on import with an annual amount of >US$250 billion in 2017 (about US$100 billion more than the second largest importing item – crude oil).

This project focuses on the key hardware technologies that are the energy-efficient ICs for enabling a smart city Macau with low-power IoT devices. The major technology breakthroughs of this project, developed by the core young team from the State-Key Lab of Analog and Mixed-Signal VLSI of University of Macau, are summarized in the following 4 main parts.

1) Wireless powering and supply regulation: Since the number of IoT devices is huge, it will be high-cost to replace the batteries, which is one of the main challenges for IoT devices. Therefore, we are solving this issue with ultralow stand-by power supply regulators and dynamic adaptation techniques to prolong the battery life. Also, we invented a reconfigurable bidirectional wireless charging technology for device-to-device charging without additional hardware, which enables the mobile devices to wirelessly charge each other or charge the wearable/IoT devices.

2) Environment energy harvesting and signal sensing and processing: Targeting for wireless sensing and healthcare applications, we have developed energy-efficient high-accuracy sensor interfaces, which can be directly powered through harvesting the ambient energy (such as solar and vibration). We have also developed customized VLSI logics operating in the sub-/near-threshold region which can significantly reduce the digital data processing power overhead.

3) Energy-efficient digitizing interface: To balance the device life time and the sensing/communication data transfer rate, analog to digital converter is one of the key building blocks in IoT system. We have developed several energy-efficient data converters with various accuracy and sampling rate suitable for a wide range of systems. We focus on the architecture innovation as well as circuit techniques and calibration techniques, and conduct theoretical studies on practical design issues in data converters.

4) Low-cost power-efficient wireless communication: A low-cost and power-efficient solution to connect a huge amount of IoT devices is one of the key challenges. Therefore, we have developed the Bluetooth Low-Energy (BLE) transmitter and receiver that can work under an ultra-low voltage of 0.2V with <6nW sleep power, which can be directly powered by harvesting energy from ambient environment. We also improved the performances of some key building blocks, e.g. VCO and MDLL, with low-power that can improve the overall

RF transceiver performances for IoT.

The knowledge developed from this project was academically transferred via 3 books, 30 IEEE journals (including 8 in the prestigious IEEE J. Solid-State Circuits), and 13 papers in the Int. Solid-State Circuits Conf. (ISSCC) 2017-2018, maintaining the leading position for our State-Key Lab as No. 1 in China and Top 5 in the world in terms of ISSCC contributions. In particular, one ISSCC paper is selected for the 2017 Takuo Sugano Award for Outstanding Far-East Paper, which is the first time that a paper from China Mainland-HK-Macau region receives this best paper award from the best electronics conference. In addition, 3 US patents have been filed. Because of our excellent research works, many IC companies in the Greater Bay Area, including Huawei Hisilicon, approached us for collaboration and consultancy.

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