ABSTRACT

POWER MANAGEMENT ICS FOR INTERNET OF THINGS, ENERGY HARVESTING AND BIOMEDICAL DEVICES
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This dissertation focuses on the power management unit (PMU) and integrated circuits (ICs) for the internet of things (IoT), energy harvesting and biomedical devices. Three monolithic power harvesting system are illustrated for different challenges of smart nodes of IoT networks. The first part proposes that an impedance tuning approach is implemented with a capacitor value modulation to eliminate the quiescent power consumption.

The second part presents a hill-climbing MPPT mechanism reuses and processes the information of the hysteresis controller in the time-domain and is free of power hungry analog circuits. Furthermore, the typical power-performance tradeoff of the hysteresis controller is solved by a self-triggered one-shot mechanism. Thus, the output regulation achieves high-performance and yet low-power operations as low as 12 µW.

The third part introduces a reconfigurable charge pump is introduced to provide the hybrid conversion ratios (CRs) as 1⅓× up to 8× for minimizing the charge redistribution loss. The reconfigurable feature also dynamically tunes to maximum power point tracking (MPPT) with the frequency modulation, resulting in a two-dimensional MPPT. Therefore, the voltage conversion efficiency (VCE) and the power conversion efficiency (PCE) are enhanced and flattened across a wide harvesting range as 0.45 to 3 V.

For the biomedical devices, this dissertation presents a novel cost-effective automatic resonance tracking scheme with maximum power transfer (MPT) for piezoelectric transducers (PT). The proposed tracking scheme is based on a band-pass filter (BPF) oscillator, exploiting the PT's intrinsic resonance point through a sensing bridge. It guarantees automatic resonance tracking and maximum electrical power converted into mechanical motion regardless of process variations and environmental interferences. Thus, the proposed BPF oscillator-based scheme was designed for an ultrasonic vessel sealing and dissecting (UVSD) system. The sealing and dissecting functions were verified experimentally in chicken tissue and glycerin.

Furthermore, a combined sensing scheme circuit that allow multiple surgical tissue debulking, vessel sealer and dissector (VSD) technologies to operate from the same sensing scheme board. Its advantage is that a single driver controller could be used for both systems simplifying the complexity and design cost.