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Sub-µW Oscillator-Less WiFi Backscattering Transmitter Reusing RF Signal for Harvesting and Sensor-Less Motion Detection with Battery-Less Smart Tag Demonstration

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ABSTRACT: Backscattering wireless transmitters have recently gained wide interest in view of their low power consumption and potential for purely-harvested operation, as well as their easy integration in wireless environments using WiFi/BLE access points. Given the power-hungry nature of on-chip frequency synthesis in backscattering, the PLL-less WiFi transmitter architecture reduces power to a few µW. The key goal of this work is to enable simultaneous reuse of the incoming RF signal for backscattering communications, harvesting and sensing via 1) further WiFi TX power reductions down to the unexplored sub-µW range for smaller, lower-cost and truly ubiquitous communications with commodity wireless hardware, 2) RF signal exploitation for always-on motion sensing, 3) PLL/crystal-less and oscillator-less TX architecture.

System-level description

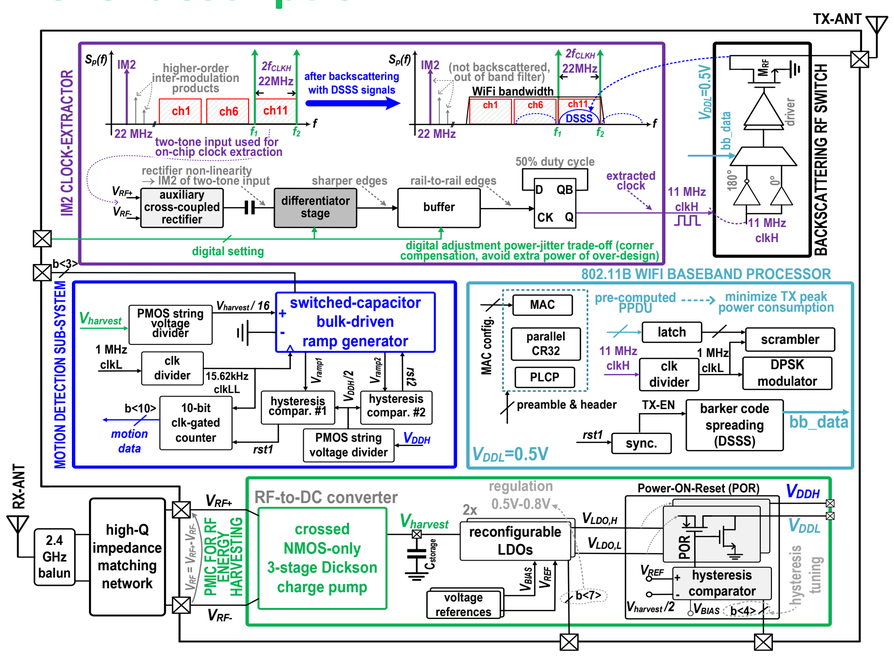

Figure 1 *– System architecture description*

The circuit includes: **clock extraction** from incoming two-tone RF incident signal (top-left), **backscattered transmission** via RF switch impedance modulation (top-right), **sensor-less motion detection** based on harvested voltage set by distance from PID (mid-left), **802.11b baseband** processor for packet assembly (mid-right), and harvesting (bottom) embedding a novel **crossed-NMOS Dickson charge pump**.

Main measurement results

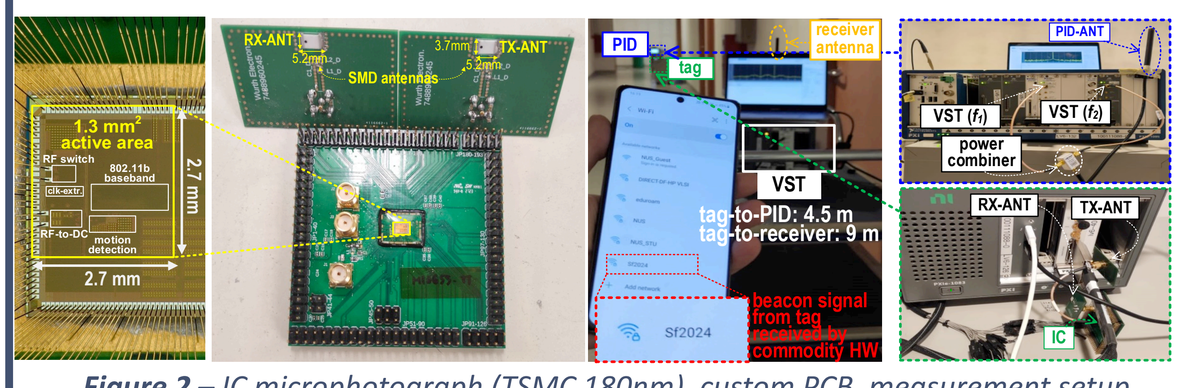

Figure 2 *– IC microphotograph (TSMC 180nm), custom PCB, measurement setup*

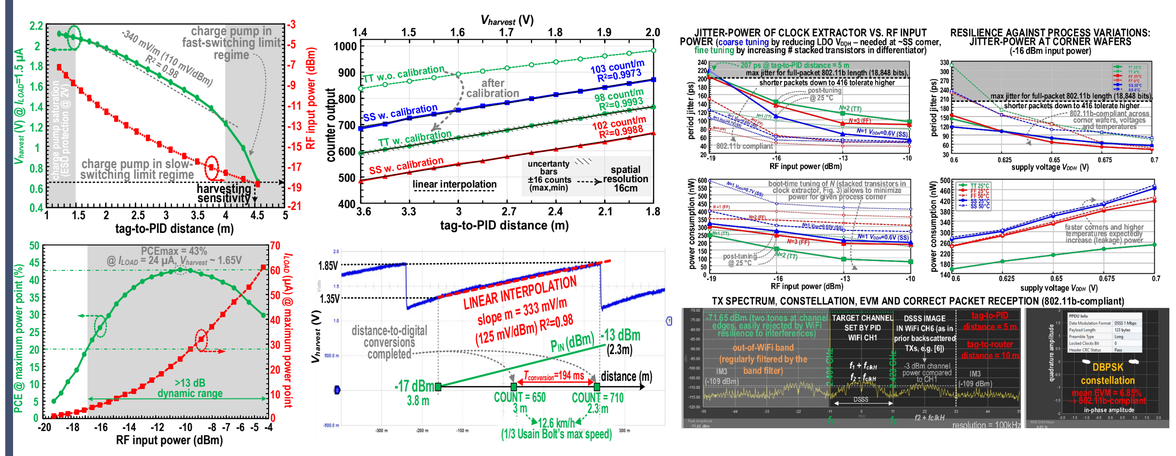

Figure 3 *– Measurement results on 1) RF-to-DC conversion trhough the novel 3-stage crossed-NMOS Dickson charge pump, 2) sensor-less position sensing, 3) 11 MHz clock extraction accuracy and jitter, 4) trasmission of 802.11b WiFi data-packets*

Conclusions

The first sub-µW 802.11b backscattering transmitter has been presented and experimentally validated under all process corner wafers (corners not considered in prior art). Its architecture reuses the same incident wave for RF harvesting, backscattering communications, clock extraction and position/motion sensing. Such reuse removes the battery, any explicit physical harvester, any power-hungry on-chip local oscillator, and off-chip motion sensor (e.g., MEMS) for aggressive miniaturization, unrestricted device lifespan, low cost and low maintenance cost for ubiquitous adoption.

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