ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY OF MICHIGAN

Electrical and Computer Engineering

ECE Final PhD Defense

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Millimeter-scale RF Integrated Circuits and Antennas for Energy-efficient Wireless Sensor Nodes

Tuesday, March 20, 2018
3:00 pm – 5:00 pm • EECS 1303

Chair: Professor David Wentzloff

Abstract:

Recently there has been increased demand for a millimeter-scale wireless sensor node for applications such as biomedical devices, defense, and surveillance. This form-factor is driven by a desire to be vanishingly small, injectable through a needle, or implantable through a minimally-invasive surgical procedure. Wireless communication is a necessity, but there are several challenges at the millimeter-scale wireless sensor node. One of the main challenges is external components like crystal reference and antenna become the bottleneck of realizing the mm-scale wireless sensor node device. A second challenge is power consumption of the electronics. At mm-scale, the micro-battery has limited capacity and small peak current. Moreover, the RF front-end circuits that operate at the highest frequency in the system will consume most of the power from the battery. Finally, as node volume reduces, there is a challenge of integrating the entire system together, in particular for the RF performance, because all components, including the battery and ICs, need to be placed in close proximity of the antenna.

This research explores ways to implement low-power integrated circuits in an energy-constrained and volume constrained application. Three different prototypes are mainly conducted in the proposal. The first is a fully-encapsulated, autonomous, complete wireless sensor node with UWB transmitter in 10.6mm3 volume. It is the first time to demonstrate a full and stand-alone wireless sensing functionality with such a tiny integrated system. The second prototype is a low power GPS front-end receiver that supports burst-mode. A double super-heterodyne topology enables the reception of the three public GPS bands, L1, L2, and L5 simultaneously. The third prototype is a fully integrated low-power transmitter in the 60-GHz band with an on-chip antenna. The transmitter efficiently integrates with the wideband slot loop antenna so that could eliminate the need external components and give freedom of channel selection.