**Title: Radiofrequency circuit design for next-generation wireless sensing and communication**

**Abstract** - Industry 4.0 is transforming how we live and work by creating a smarter and more interconnected world. Advancements in wireless connectivity, in terms of speed, capacity, reliability, security, and cost-effectiveness, are critical to support Industry 4.0 applications. This dissertation contributes to the research on radiofrequency (RF) circuits to meet modern wireless connectivity demands for low-cost, real-time, contact-free sensing and power-efficient, high-bandwidth communication.

The first part of this dissertation concerns spiral inductor-capacitor (LC) resonant sensors, which have emerged as a low-cost, rapidly scalable, and wireless solution for several real-time sensing applications in agriculture, biomanufacturing, and healthcare. Although the sensors themselves are highly cost-effective, traditional techniques to wirelessly interrogate them require expensive laboratory equipment, which are often not portable and need technical expertise to operate. Alternatively, custom readout techniques from literature suffer from high cost, high cost, narrow operating frequency range, and low range of usable distances for wireless interrogation. Hence, a new simple, low-cost, and portable readout design platform for LC resonant sensors is developed in this work. The operation of the proposed readout is theoretically analyzed to identify design constraints and tradeoffs, following which the implementation of the readout system hardware on a printed circuit board is presented. The fabricated system operates between 1 and 100 MHz, consumes 1.26 W, and experiments demonstrated reliable and repeatable operation with interrogation distances up to 5 cm.

The second part of this dissertation focuses on RF power amplifiers which form the most power and area-consuming stage of RF transmitter systems. A push-pull concurrent dual-band class-D power amplifier was previously demonstrated in literature with the potential to meet modern carrier aggregation requirements. Although experiments showed promising results, the configuration did not render itself to symbolic analysis. This work uses an alternate representation of a sum of sinusoids to analytically derive the complex Fourier series coefficients of all voltages and currents of the power amplifier, which lead to expressions for output power and efficiency, finally demonstrating a theoretical drain efficiency of 100%. Harmonic Balance simulation was used to validate the theory.

Furthermore, the push-pull architecture requires an output balun, and implementing a discrete power amplifier at GHz frequencies necessitates using a distributed balun instead of a three-wire transformer. Previous work showed that this substitution caused an efficiency degradation of the power amplifier and hypothesized that imperfect termination of a traditionally designed balun’s common mode signals was the culprit. This dissertation uses a mixed-mode S-parameter analysis to derive the common mode termination requirements of distributed baluns for concurrent dual-band operation. Subsequently, a generalized design modification procedure is developed for dual-band distributed baluns to enable concurrent use operation. The modification prevents common mode power loss without disturbing the balun’s other performance metrics. A concurrent dual-band tapped stepped impedance balun was designed and tested to validate the developed approach.