Title

Multi-Mode Receiver RF Front-Ends for Multi-Standard Applications

Abstract

The prosperity of wireless communication, the diversity of its standards and the endless demand from its customers for lower cost and better services suggest that a future wireless terminal should be able to support multiple bands, standards and applications. Currently, each wireless standard requires one specific radio system (transceiver) for communication, a viable but costly solution. To solve the problem, it is favorable to share circuit blocks with similar functionality between different standards. This brings the concept of Software-Defined Radio (SDR) which is meant to realize a single flexible transceiver that can be reconfigured to cope with many standards on demand. The PhD investigates the feasibility of designing such flexible multi-mode radio circuits, specifically, for the Radio-Frequency (RF) part of the receiver chain, in other words, the receiver RF front-end.

The Low-Noise Amplifier (LNA), as the first active circuit in the receiver chain, is very critical for the performance of the complete receiver. This work demonstrates a 3-5GHz wideband LNA on board, taking into account many practical design problems like Electrostatic Discharge (ESD) protection, package parasitics, and stability. Inductive degeneration at the LNA’s input stage achieves simultaneous noise and power matching for optimum noise figure while interstage gain roll-off compensation flattens the gain response.

The second type of flexibility, generally desired in an LNA, is variable gain in order to improve the system dynamic range. This gain flexibility is illustrated in a 5GHz switchable-gain LNA which features a low-noise high-gain branch and a separate inductorless low-gain branch that imposes little area penalty. The low-gain branch boosts linearity and reduces power consumption in the low-gain mode.

Furthermore, the work exhibits both frequency and gain flexibility in a switchable narrow-band receiver RF front-end which covers 1.8GHz and 5-6GHz bands. The front-end employs the direct-conversion architecture and consists of one LNA and two wideband mixers in quadrature, all of which have switchable gain. A low-loss off-chip RF Microelectromechanical Systems (MEMS) series switch placed before the LNA selects different narrow-band input impedance matching networks for different standards. As a result, the LNA has narrow-band input matching in each band and is therefore more robust to interferers than LNAs with wideband matching. The chip design and board-level implementation verify the MEMS-enabled flexible receiver RF front-end with switchable narrow-band impedance matching and switchable gain.

The PhD work successfully shows that careful circuit design trade-offs and low-loss low-parasitic RF components will allow of building multi-mode flexible RF circuits with minimal penalty.