Abstract

The high potential of portable wireless communication industry and a rapid advancement of low-cost deep sub-micron silicon fabrication technologies, have raised interest in radio frequency (RF) integrated circuit (IC) design and optimization. Spiral inductor is one of the key building blocks of RF ICs which dominate the circuit performance. As a result, accurate modeling and synthesis of spiral inductors on lossy silicon substrate is becoming increasingly important for design and optimization of RF ICs. This thesis work focuses on these aspects of on-chip spiral inductors. Although various models and modeling techniques have been reported, most of them lack the capability of capturing broadband characteristics of a spiral inductor. This thesis presents a 1-π compact broadband lumped element model that can accurately capture inductor behavior over a frequency range up to 20 GHz. It includes a substrate network and a high resistive component to accurately capture the substrate eddy current effect as well as skin and proximity effects at high frequency. A particle swarm optimization (PSO) based parameter extraction procedure has been developed for determining model parameters from measured data. Broadband accuracy and scalability of this model have been verified with on-silicon data of spiral inductors. The equivalent circuit model consisting of frequency-independent circuit elements is suitable for use in circuit simulators.

This research work also presents a fast and reliable spiral inductor synthesis procedure using artificial neural network models in combination with a particle swarm optimizer. Trained neural models have been developed from electromagnetic (EM) simulation data of spiral inductors and the developed models show good accuracy. In the proposed synthesis procedure, PSO generates inductor

geometries within the given design space and electric parameters of these generated inductors are computed using neural models. Use of trained neural model replaces EM simulation requirements in the synthesis loop. Since the synthesis procedure generates multiple solutions for a given target, the designer is able to make trade-off between competing objectives. The synthesis results show good agreement with EM simulation.

Using the optimized layout dimensions of spiral inductor obtained by synthesis approach, an LC-tank voltage controlled oscillator is designed for 2.5 GHz applications in a 0.18 μm CMOS technology. Our broadband inductor model is incorporated for circuit simulation in Cadence environment.