Real-time Automatic Tuning of the Centre Frequency and the Q-Factor in CMOS LC Filters

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CMOS analogue filters can be implemented with several structures including active-RC, transconductance-C, MOSFET-C, and LC filters. CMOS LC filters have the advantage of being less sensitive to parasitic capacitances as they can actually be absorbed into the total reactance required for the design frequency [1]. This enables them to be utilized in gigahertz range applications; however, on-chip inductors have limited Quality (Q) factor as a result of ohmic losses in the metal contacts, the lossy substrate due to the bulk resistance, and the feasible number of turns. Therefore, on-chip inductors in a standard RF CMOS process have Q-factors of around 15, which results in limited selectivity. One way to enhance the Q-factor of an LC resonator is to utilize an active device to generate a negative resistance that compensates for the resistive losses of the lossy inductor.

Q-enhanced LC filter technology offers a promising approach to remove the bulky off-chip RF filter in wireless receivers. However, the complexity and inaccuracy of the centre frequency and Q-tuning have hindered utilization of this technology in commercial applications. Real-time automatic tuning of the centre frequency and the Q-factor is not only required for multi-standard radio receiver applications, but also for the discrepancy in the passive element values due to process and temperature variations. The two common methods available for the automatic tuning of analog filters are the Master/Slave (M/S) tuning [3] and the self-tuning [4]. The M/S tuning scheme consumes more power, occupies larger chip area, and suffers from matching problems between the master and the slave filter. In self-tuning schemes, the filter is periodically removed from the circuit and tuned with the aid of a tuning control circuitry that requires a frequency reference [1]. Nevertheless, the self-tuning scheme suffers from the complexity of an additional reference clock generation circuit and the feedthrough caused by the switches between the signal path and reference clock signal [5].

The goal of this Ph.D. proposal is to develop and implement a novel low-complexity real-time tuning scheme for CMOS Q-enhanced LC filters in an effort to eliminate the need for the undesirable off-chip devices such as the expensive SAW filters and pave the way for the commercialization of multi-standard wireless receivers.

Tools Required: MATLAB/SIMULINK and Agilent ADS for algorithm development and system-level design. Cadence Design Environment for the transistor-level design and CMOS chip-level layout for prototyping.

Bibliography


