Abstract
Performance failure due to aging is an increasing concern for RF circuits. While most aging studies are focused on the concept of mean-time-to-failure, for analog circuits, aging results in continuous degradation in performance before it causes catastrophic failures. In this regard, the lifetime of RF/analog circuits, which is defined as the point where at least one specification fails, is not just determined by aging at the device level, but also by the slack in the specifications, process variations, and the stress conditions on the devices. In this dissertation, firstly, a methodology for analyzing the performance degradation of RF circuits caused by aging mechanisms in MOSFET devices at design-time (pre-silicon) is presented. An algorithm to determine reliability hotspots in the circuit is proposed and design-time optimization methods to enhance the lifetime by making the most likely to fail circuit components more reliable is performed. RF circuits are used as test cases to demonstrate that the lifetime can be enhanced using the proposed design-time technique with low area and no performance impact. Secondly, in-field monitoring and recovering technique for the performance of aged RF circuits is
discussed. The proposed in-field technique is based on two phases: During the design
time, degradation profiles of the aged circuit are obtained through simulations. From
these profiles, hotspot identification of aged RF circuits are conducted and the circuit
variable that is easy to measure but highly correlated to the performance of the primary
circuit is determined for a monitoring purpose. After deployment, an on-chip DC monitor
is periodically activated and its results are used to monitor, and if necessary, recover the
circuit performances degraded by aging mechanisms. It is also necessary to co-design the
monitoring and recovery mechanism along with the primary circuit for minimal
performance impact. A low noise amplifier (LNA) and LC-tank oscillators are fabricated
for case studies to demonstrate that the lifetime can be enhanced using the proposed
monitoring and recovery techniques in the field. Experimental results with fabricated
LNA/oscillator chips show the performance degradation from the accelerated stress
conditions and this loss can be recovered by the proposed mitigation scheme.