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Parameter Variation Sensing and Estimation in Nanoscale Fabrics

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Abstract

Parameter variations introduced by manufacturing imprecision are becoming more influential on circuit performance. This is especially the case in emerging nanoscale fabrics due to unconventional manufacturing steps (e.g., nano-imprint) and aggressive scaling. These parameter variations can lead to performance deterioration and consequently yield loss.

Parameter variations are typically addressed pre-fabrication with circuit design targeting worst-case timing scenarios. However, this approach is pessimistic and much of performance benefits can be lost. By contrast, if parameter variations can be estimated post-manufacturing, adaptive techniques or reconfiguration could be used to provide more optimal level of tolerance. To estimate parameter variations during run-time, on-chip variation sensors are gaining in importance because of their easy implementation.

In this thesis, we propose novel on-chip variation sensors to estimate variations in physical parameters for emerging nanoscale fabrics. Based on the characteristics of systematic and random variations, two separate sensors are designed to estimate the extent of systematic variations and the statistical distribution of random variations from measured fall and rise times in the sensors respectively. The proposed sensor designs are evaluated through HSPICE Monte Carlo simulations with known variation cases injected. Simulation results show that the estimation error of the systematic-variation sensor is less than 1.2% for all simulated cases; and for the random-variation sensor, the worst-case estimation error is 12.7% and the average estimation error is 8% for all simulations.

In addition, to address the placement of on-chip sensors, we calculate sensor area and the effective range of systematic-variation sensor. Then using a processor designed in nanoscale fabrics as a target, an example for sensor placement is introduced. Based on the sensor placement, external noises that may affect the measured fall and rise times of outputs are identified. Through careful analysis, we find that these noises do not deteriorate the accuracy of the systematic-variation sensor, but affect the accuracy of the random-variation sensor.

We believe that the proposed on-chip variation sensors in conjunction with post-fabrication compensation techniques would be able to improve system-level performance in nanoscale fabrics, which may be an efficient alternative to making worst-case assumptions on parameter variations in nanoscale designs.

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