Temperature and On-chip Crosstalk Measurement using Ring Oscillators in FPGA

Martin Gag, Tim Wegner, Ansgar Waschki, Dirk Timmermann

Motivation

- Power density
- Process variations
- Heterogeneous Systems-on-Chip

> Thermal Imbalances
- Thermal Monitoring
- Need small distributed sensors
- Compile temperature map
- Enable thermal management

- Computational resources
- Communicational resources
- Capacitances
- Variations

> Signal Integrity and Aging
- Need to sense delay
- + Coupling induced delay
- Test circuit on FPGA

Measurement of On-chip Temperature and Crosstalk

Temperature sensitive ring oscillator with frequency counter:

\[ V/I = \frac{V_{th} + \alpha V_T \cdot (T - T_0)}{V_T} \]

\[ \alpha = \mu \cdot \left( \frac{T}{T_0} \right)^\alpha \]

- Influence of \( \mu \) is dominating
- Overall a linear relationship is assumed
- Only true for certain temperatures:

\[ T_{\text{in}} = 10 \times T \]

Capacitive coupling
- Activity on neighboring wires influences voltage level
- Induced delay can be positive or negative

Results of Measurements

Coupling induced delay is measured
All crosstalk patterns can be differentiated

Scattering an array of sensors is possible
Calibration of multiple sensors could be tricky

- Runtime Thermal Management,
  Temperature Aware Mapping,
  ...

University of Rostock, Germany
Institute of Applied Microelectronics and Computer Engineering