NAME: MOINUDDIN A. SAYED
DEPT: COMPUTER ENGINEERING
DEGREE: MS
TITLE: Mitigating the Impacts of Workload Variation on Ring Oscillator-based Thermometers

ABSTRACT

Thermal issues have resulted in growing concerns among industries fabricating various types of devices, such as Chip Multiprocessors (CMP) and reconfigurable hardware devices. To reduce passive cooling costs and eliminate the need to package for worst-case temperatures, dynamic thermal management (DTM) techniques are being devised to combat thermal effects. Reliable runtime measurement of device temperature is necessary for implementing DTM techniques. Ring oscillators have often been used for on-chip Field Programmable Gate Array (FPGA) temperature measurement due to their strong linear temperature dependence and compact design using available spare reconfigurable resources.

A major problem in using ring oscillators to measure temperature, however, is that their frequency of oscillation is affected by changes in device core voltage and current distribution, induced by changes in application workload. The need, then, is to have a workload-compensated ring oscillator-based thermometer for reconfigurable devices.

This work performs a characterization of the ideal as well as non-ideal effects of workload variation on ring oscillator frequency response. Where non-ideal refers to impacts on ring oscillator oscillation frequency due to phenomena other than the workload's impact on device temperature. The data obtained from this characterization is used to compensate for these non-ideal effects. A complete hardware-software solution is implemented to collect temperature and power related data along with ring oscillator frequency response to varying workload configurations. The characterization results show an error of approximately 1°C in the estimated temperature for every 8.6mA change in current drawn from the supply on a Xilinx Virtex-5 LX110T FPGA, with respect to the current draw measured while running a baseline workload during thermometer calibration. This lead to a maximum error of ~74°C for the workloads evaluated. The compensation technique implemented is shown to reduce this error to ~2°C.

In addition, a potential issue with using the Xilinx System Monitor to measure die temperature at high temperatures is observed. The System Monitor reported temperatures show a deviation of up to 20°C from temperatures obtained using a case-mounted thermal probe.