

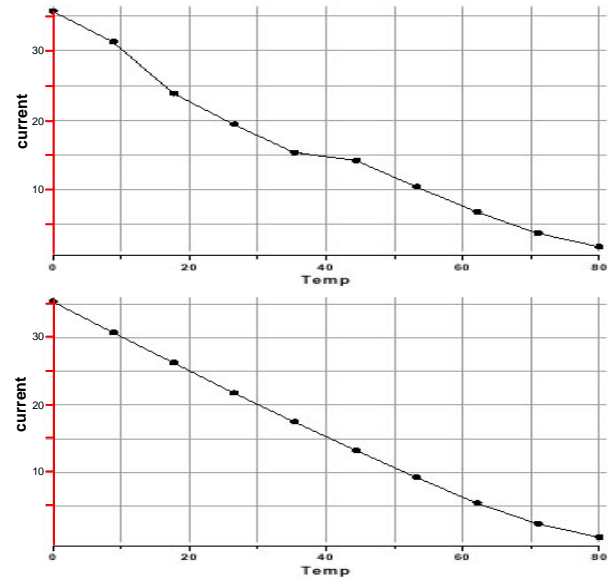
Circuit & Application

Flash Memory Array (32 transistors) - statistical analysis and optimization of read current variation. Process technology used was 90nm.

Problem Formulation and Goals

The read and write current of the flash memory array depended strongly on the operating conditions. This problem was caused by leakage current in the transistor-off mode which created large variations, especially at high temperatures.

The problem could only be solved with an accurate estimation of the bit error rate to determine values for the hard coded registers. Furthermore it was necessary that the analysis and optimization cover the entire range of operating conditions. This was not possible with conventional analysis and optimization methods.



Solution using WiCkED

Using WiCkED the problem was solved in three analysis and optimization steps:

Step 1 — Circuit Modeling

A circuit model was defined to determine the worst-case parameter sets for the write process and the worst-case variation of the read current. Based on this the specifications for the read process of the circuit were defined and analyzed.

Step 2 — Statistical Simulation

Based on measurement results of actual circuit samples, transient simulations were used to define terminal voltages for the initial states of the transistors.

The initial voltages were not measurable on real circuit transistors. Therefore they could only be found by simulation. For all the array transistors they were modeled with statistical parameters and the currents were optimized with respect to the threshold voltage of the transistors.

Step 3 — Worst-Case Optimization

Based on simulation results WiCkED reduced the variation in currents over temperature. The analysis was repeated to adjust the technology parameters of the process.

WiCkED Results

- WiCkED's worst-case optimization achieved a design with robustness of 6 sigma.
- After using WiCkED's enhanced circuit and statistical analysis and optimization a key result was that the optimum for the read voltage is higher than the initial assumed value for the mean values of the threshold voltage distribution.
- Conventional methods like Monte Carlo alone are not capable to actively optimize a circuit to reach such a high robustness value.

Flash Memory Array Optimization Flow with WiCkED

