A 10-nW, 12-Bit Accurate Analog Storage Cell with 10-aA of Leakage

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Medium-term analog storage offers a compact, accurate, and low-power method of implementing temporary local memory that can be useful in adaptive circuit applications. The performance of these cells is characterized by the sampling accuracy and voltage droop that can be achieved with a given level of die area and power. Hand calculations suggest past implementations have not achieved minimum voltage droop due to uncompensated MOS leakage mechanisms. In this research, the dominant sources of MOS leakage were experimentally characterized in a standard 1.5-µm CMOS process using an on-chip current integration technique, focusing specifically on the 1fA-to-1aA current range. These measurements revealed an accumulation-mode source-drain coupling mechanism that can easily dominate diode leakage under certain bias conditions, and may have limited previous designs. A simple rule-of-thumb is offered for avoiding this leakage effect, leading to a novel ultra-low leakage switch topology. A differential storage cell incorporating this new switch achieves an average leakage of 10aA at room temperature, an 8× reduction over past designs. The cell loses one bit of voltage accuracy, 700µV on a 12-bit scale and 11.3mV on an 8-bit scale, in 3.3 minutes and 54 minutes, respectively. This represents a 15× increase in hold time at these voltage accuracies over the lowest-leakage cell to date, in only 92% of the area. Since the leakage is independent of amplifier bias, the cell can operate on as little as 10nW of power. Initial measurements from a 0.5µm implementation of the switch topology demonstrate sub-attoamp leakage levels in this technology, suggesting the leakage of this switch topology decreases, approximately, with the square of process feature size.

Figure 1: Die photograph (2.2mm × 2.2mm). A differential analog storage cell, which exhibits 10aA net leakage current at room temperature, is circled in white.

Figure 2: Differential cell leakage with a 2.5pF hold capacitor.

REFERENCES:

