IDEC Chip Design Contest

Adjustable Majority Voting Algorithm for Stability Improvement in SRAM-based CMOS PUFs

Kwangmin Yu, Woojin Jeong, Jimin Yoo, Hyunyoung Yoo, Su-Hyeon Kim,
Yeonsu Kim, Myung Hyun Jeon, Eunji Yoo, and Jae-Won Nam
Department of Electronic Engineering, Seoul National University of Science and Technology

Abstract

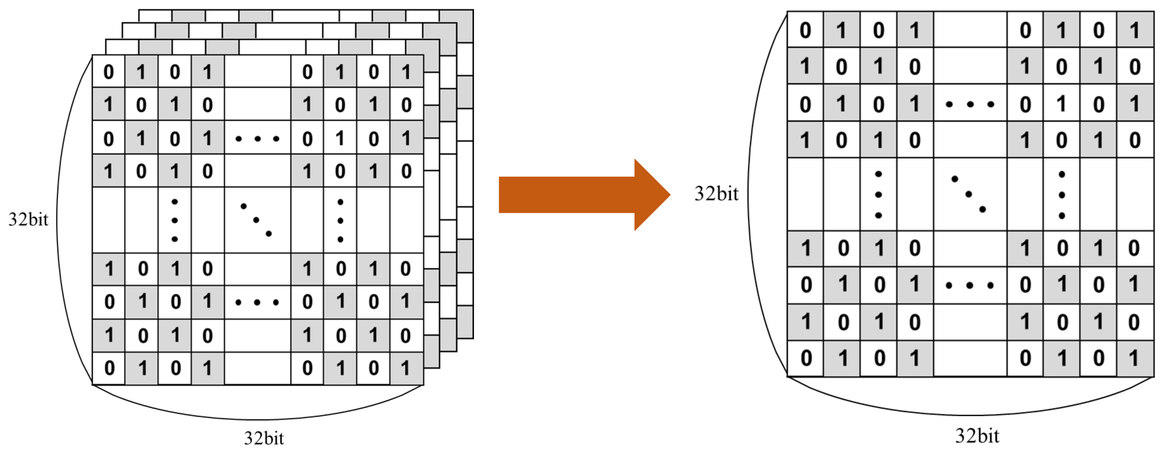
The SRAM-based CMOS physically unclonable function (PUF) employing the adjustable majority voting algorithm is presented. In memory-based PUFs with limited challenge-response pairs (CRPs), output stability is critical. To achieve a target bit error rate (BER), an error-correction algorithm using a user-configurable majority voting scheme is implemented using a data accumulator and majority selector. Fabricated in 28nm CMOS, the 1024-bit SRAM PUF core achieves 24.12 μm²/bit area and 0.09 pJ/bit energy efficiency. With 2^{10}+1 repetitions, unstable bits reduce from 31.54% to 8.40%, and BER improves from 6.28% to 0.93%. Utilizing all SRAM bitcells, unstable bits and BER improve by 73.37% and 85.19%, respectively, at 1.0 V and 25°C. Consequently, masking only about 1% of the error cells leads to a zero BER. Furthermore, the inter-die and intra-die Hamming distances are 49.84% and 1.37% (1,000 evaluations), respectively.

Concept of technique

◆ **Conventional error-correction algorithm**

- Discard unstable SRAM bit-stream ➡ “Reduction of active bits”

◆ **Majority Voting algorithm**

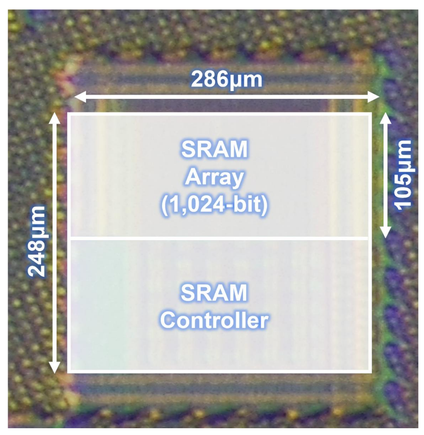


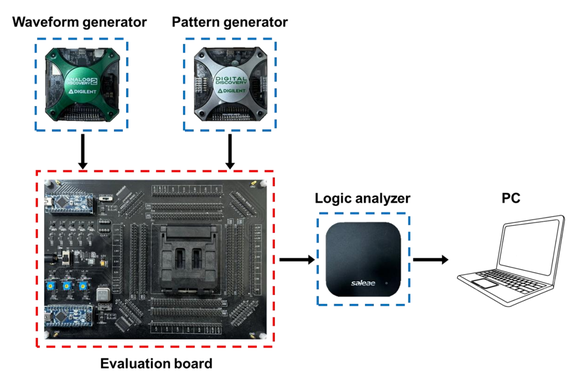
- Set the number of iteration cycles using the ‘user-configurable option’.

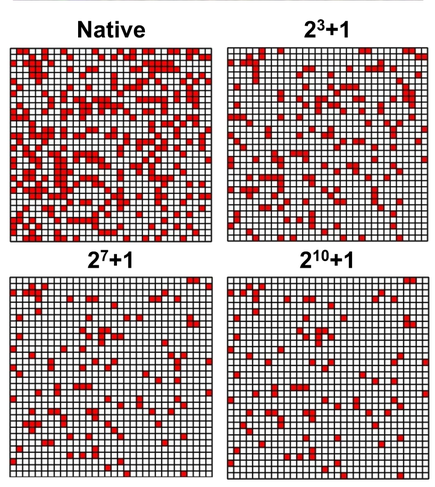
- The chip internally averages multiple SRAM cell trials and outputs a single 32x32 bit array.

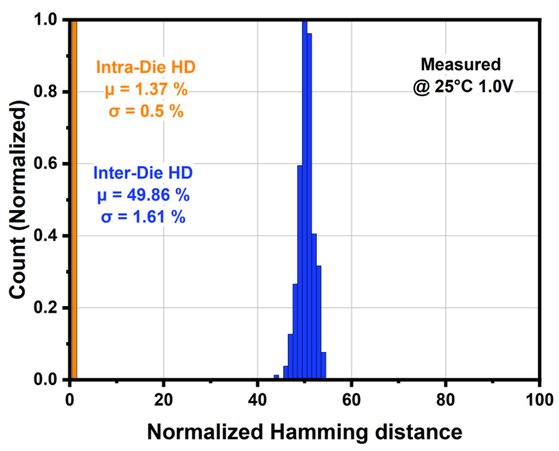
- Increasing the number of trials mitigates noise, yielding a more stable SRAM cell output and utilizing a more active bits.

Measurement Setup & Results

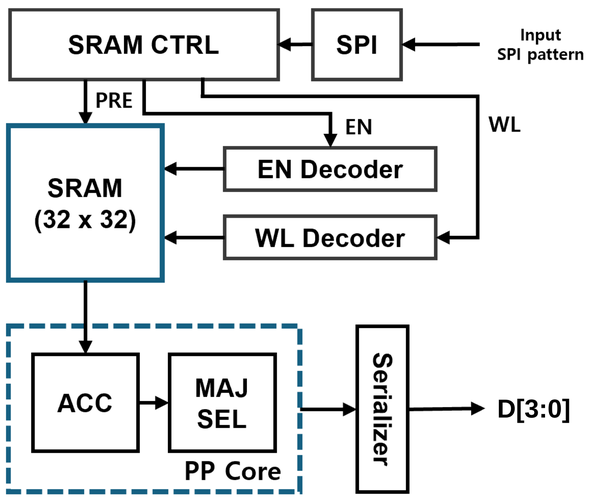


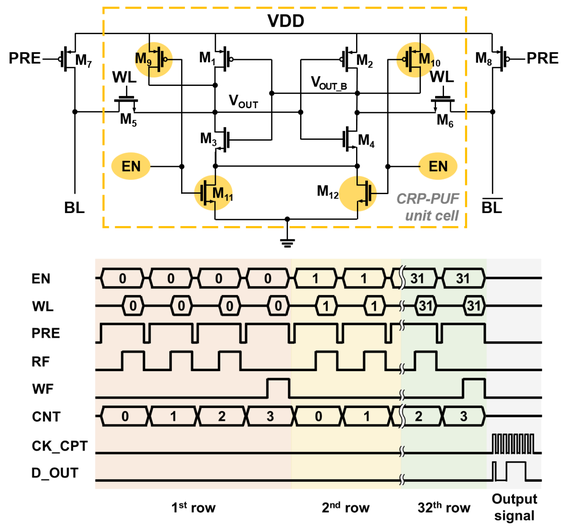






Overall Architecture





◆ **32 x 32 SRAM PUF with multiple CRPs (1.6E+8).**

◆ **An adjustable majority voting scheme is implemented using an accumulator and majority selector.**

◆ **The prototype is fabricated in 28nm technology.**

Comparison

	This work	TCAS’2022	VLSI’2023
CMOS Technology	28nm	40nm	28nm
Pre-Stabilization BER (%)	6.28	5.27	-
After-Stabilization BER (%)	0.93	0.8	0.42 / 2.25
Active bit ratio (%)	100	70.24	87.5 / 39.9
Intra-HD (%)	1.37	-	1.87 / 2.95
Inter-HD (%)	49.84	49.84	50.11 / 50.09

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