IDEC Chip Design Contest

Ring Oscillator based Strong Physical Unclonable Function Using Reconfigurable Inverter with Response Stability Detection Circuit

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Abstract

- Randomness of response is an important performance of PUF (Physical Unclonable Function).
- The proposed strong PUF creates numerous CRPs (Challenge Response Pairs).
- BER performance of a silicon PUF is inadequate to be utilized in information security application.

Proposed Strong PUF based on Ring Oscillator

- The proposed circuit is independently selected for each transistors, which has 4.3×10^9 CRP capacity.
- The ring oscillator based PUF has randomness of 49.78% (Monte Carlo 2000-sampling).
- The detection method is adopted to satisfy BER of 0%.

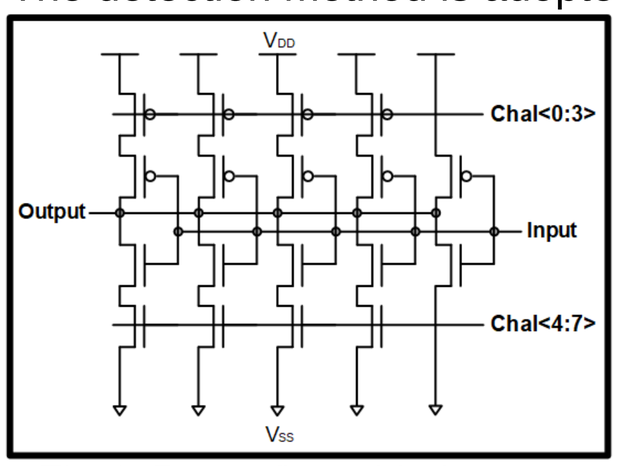

Fig 1. Reconfigurable Inverter

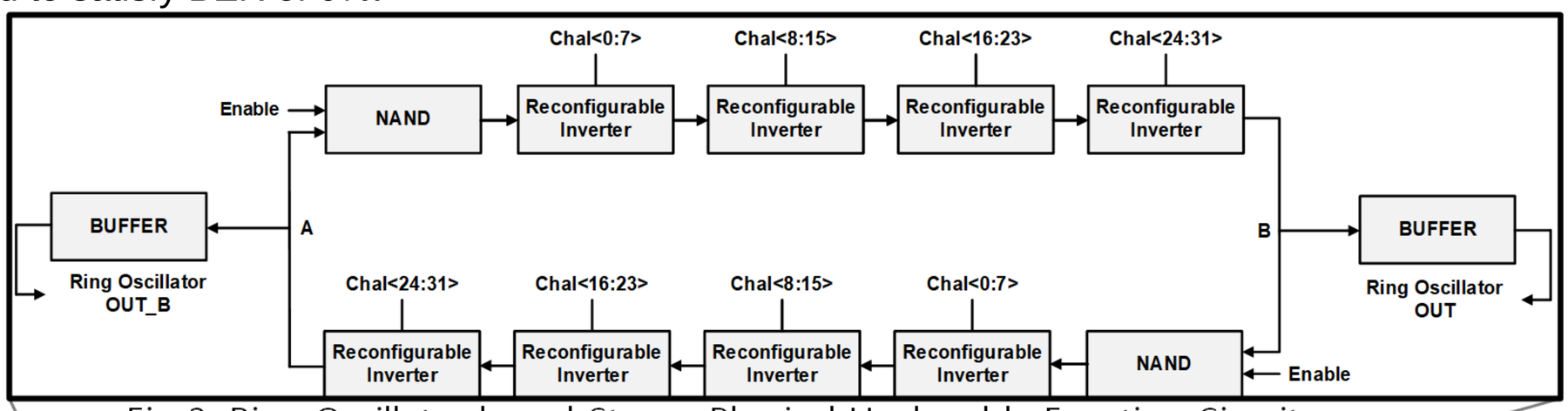

Fig 2. Ring Oscillator based Strong Physical Unclonable Function Circuit

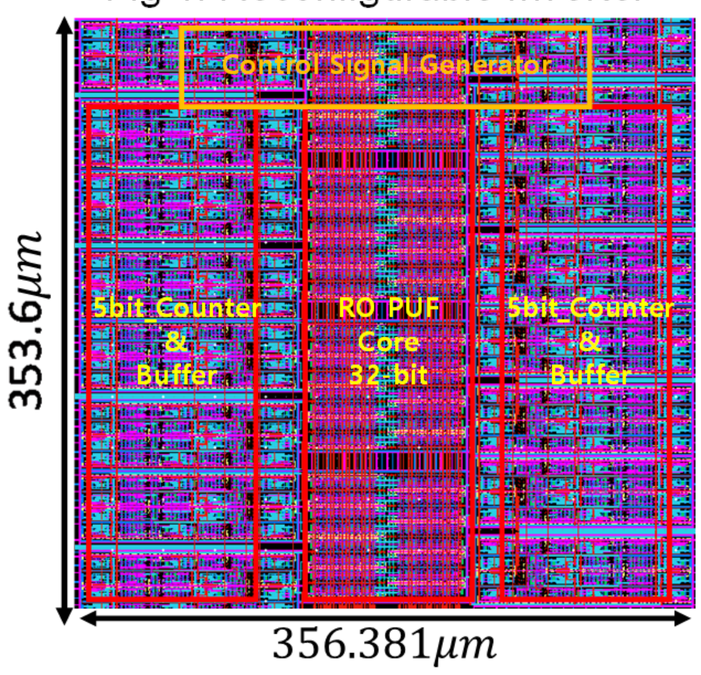

Fig 3. Designed Chip Layout

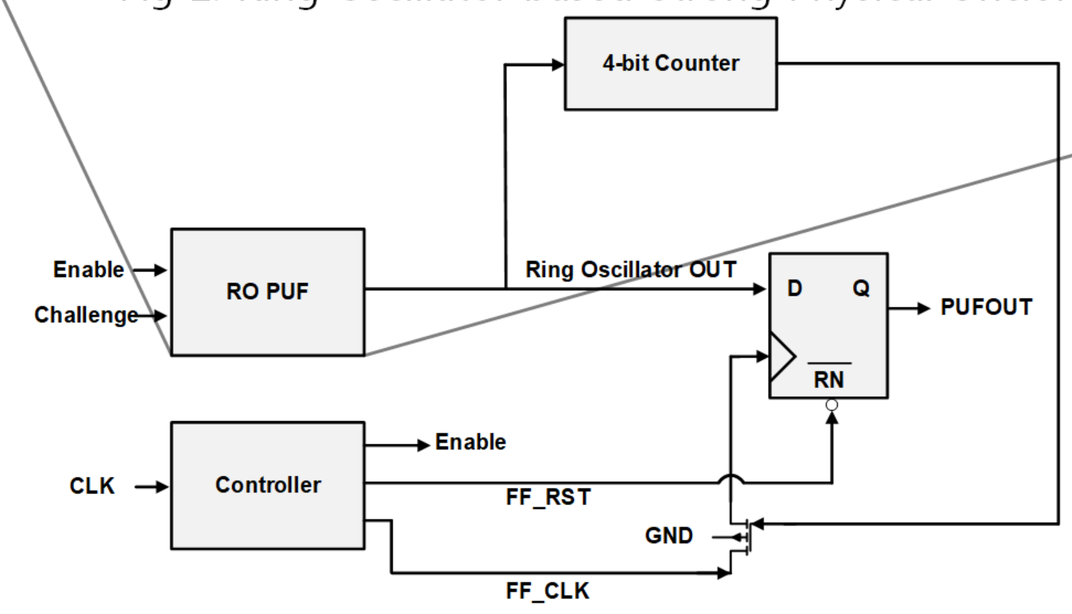

Fig 4. Detection Circuit for Response Stability

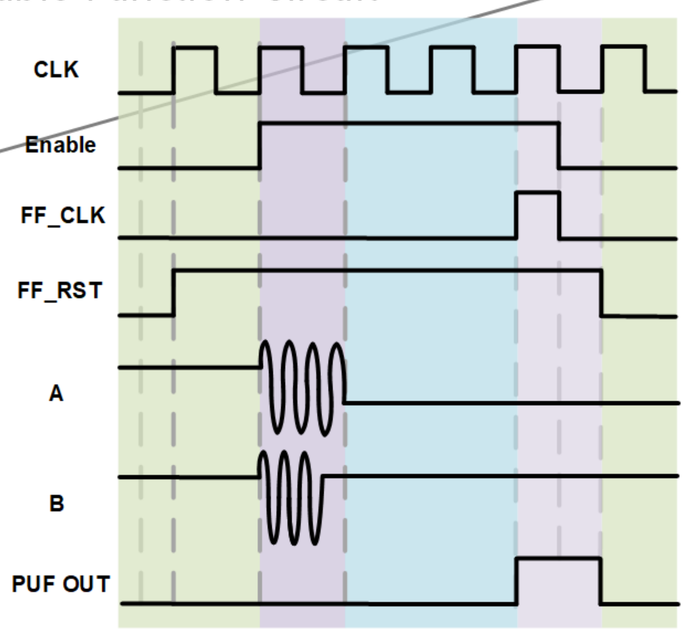

Fig 5. Response Timing Diagram

Layout & Simulation Results

- This circuit was designed in Samsung 65nm CMOS process, its layout is shown in Fig. 3.
- Area/bit occupies 3938.01μm^2 with throughput of 50Mb/s on a single cell.
- The proposed chip generates 100% stable output under random power noise of +-30mV, tested by 10K samples.

Conclusion

- The proposed strong PUF using ring oscillator achieves high randomness (49.78%).
- The detection circuit is adopted to improve the response stability.
- The circuit shows improved randomness and stability compared to the other research.

Metric/Research (Validation Method)	This work (Simulation)	*DATE* '17 Tao et al. (Simulation)	*IEEE T-SCM* '18 Yanambaka et al. (Simulation)	*IEEE T-VLSI* '19 Zhang et al. (Experimental)
Process	65nm CMOS	65nm CMOS	10nm FinFET	65nm CMOS
Topology	RO	PFD-based RO-PUF	RO	MPUF
Bit-Width of Challenge [bit]	32	128	128	256
Bit-Width of Response [bit]	32	128	1	1
Number of CRPs	4.3×10^9	6.8×10^{10}	1.8×10^{19}	5120
Post-Process BER (%)	**0**	0.53	1.9	5.2
Uniqueness (%)	**49.78**	49.97	74	50.42
Average Power (μW)	58.8	36.4	121	11.2

Table 1. Performance comparison table with state-of-the-art

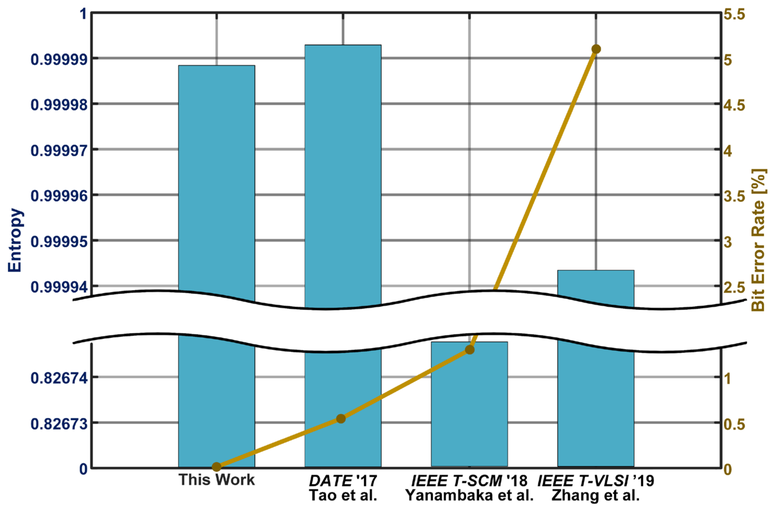

Fig. 6. Entropy and BER analysis

Acknowledgments

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