Industry 4.0 Security Trust Anchors: Considering Supply Voltage Effects on SRAM-PUF Reliability

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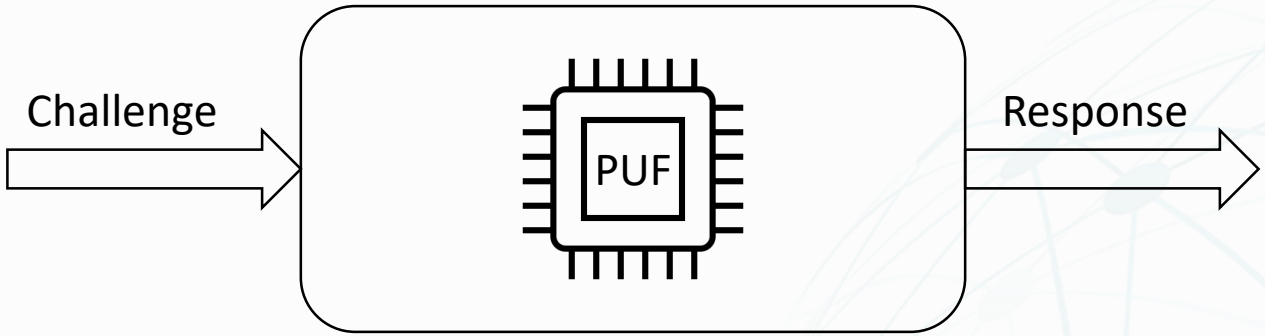
Industrial Internet Of Things

- Intelligent networking of Machines and processes in industry
- Linking Big Data and the Internet of Things
- Internet as the core technology
- Sensible Data
- Things as small, energy-limited actors
- Industrial environment with different conditions

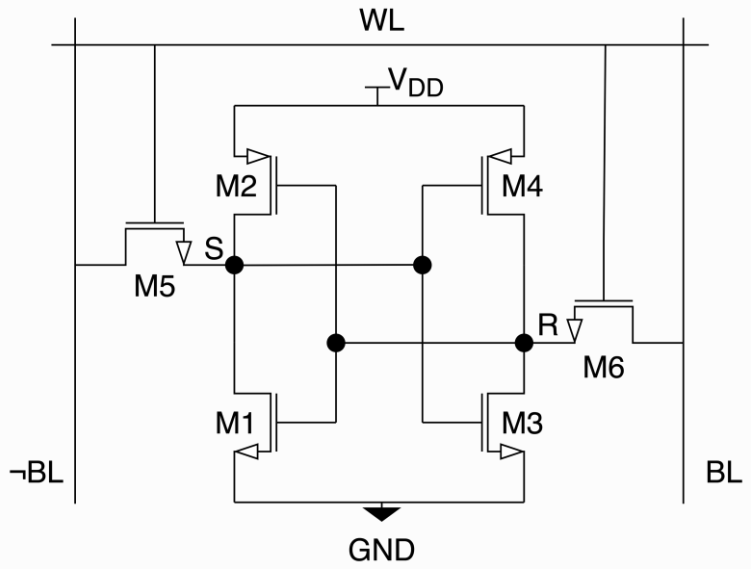
Physically Unclonable Function

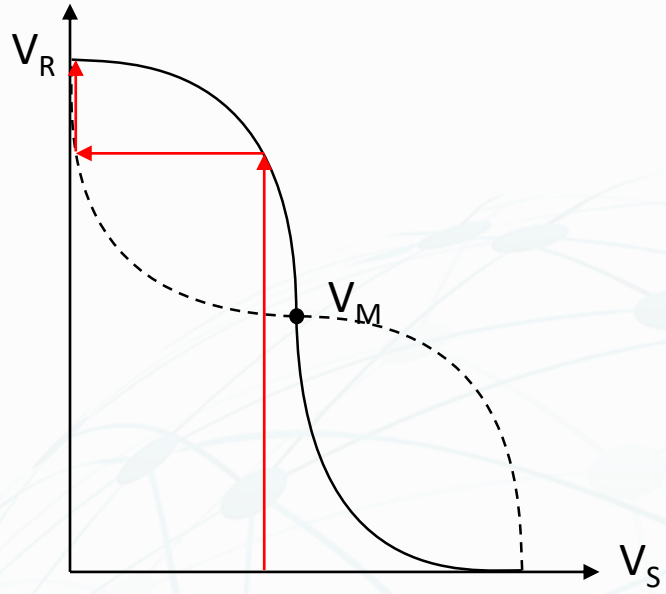
„[...] physical entity whose behaviour is a function of its structure and the intrinsic variation of its manufacturing process“
-Basel Halak-



- No need to store keys
- Lightweight
- Technical Fingerprint

Static Random Access Memory

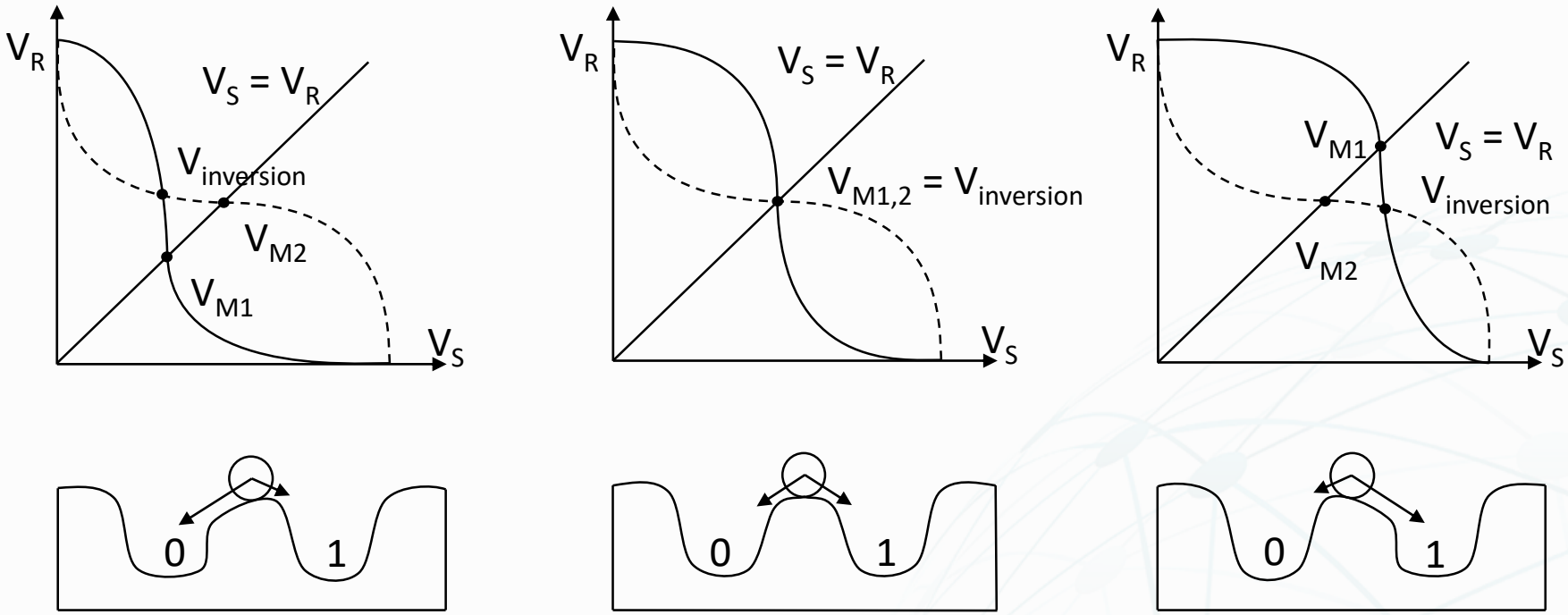




- Volatile memory
- Included in almost every µC
- CMOS Technology
  → Power loss ∝ frequency

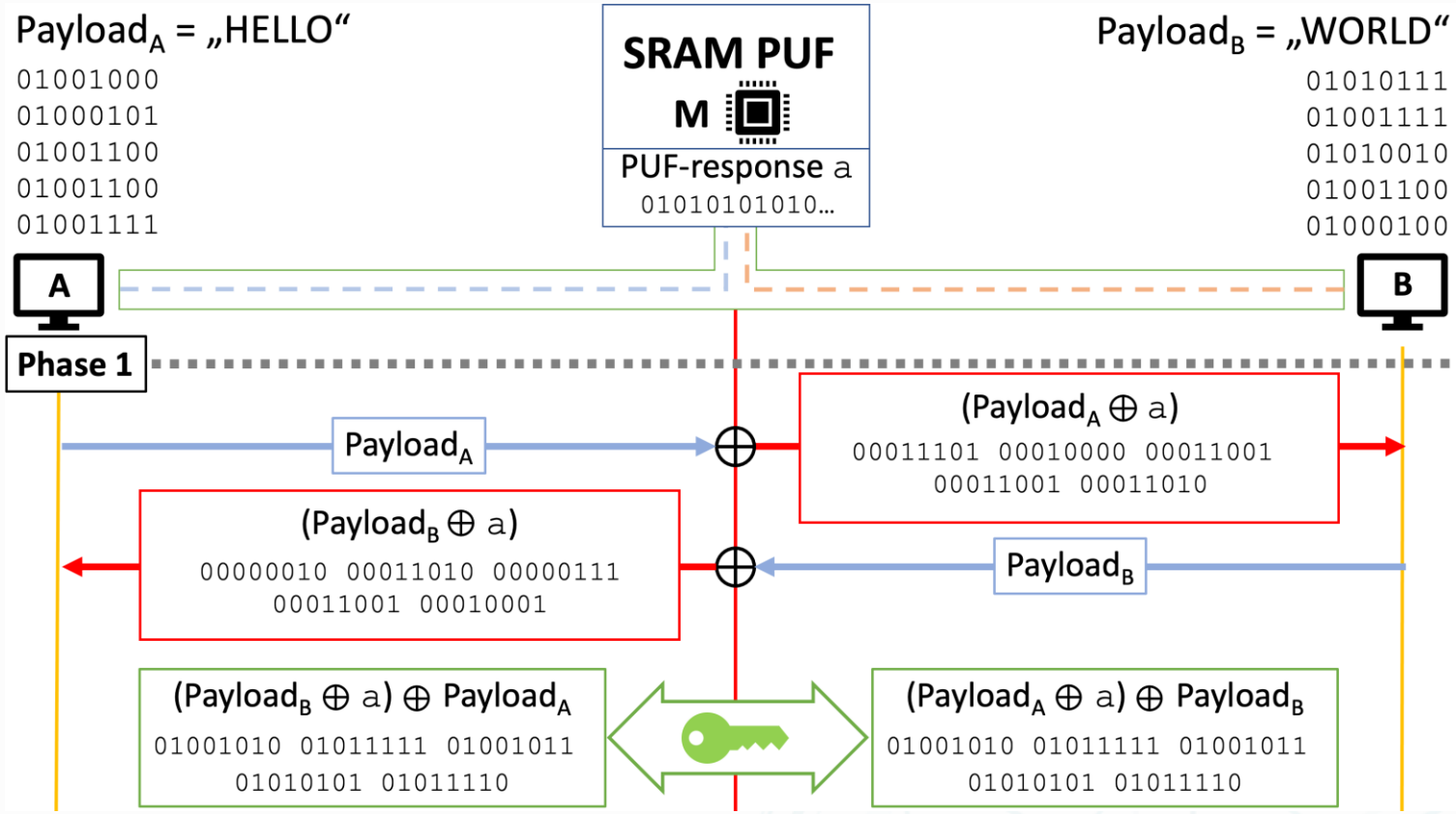
- Every cell stores one Bit
- 2 coupled inverter
- Bistable system

SRAM PUF

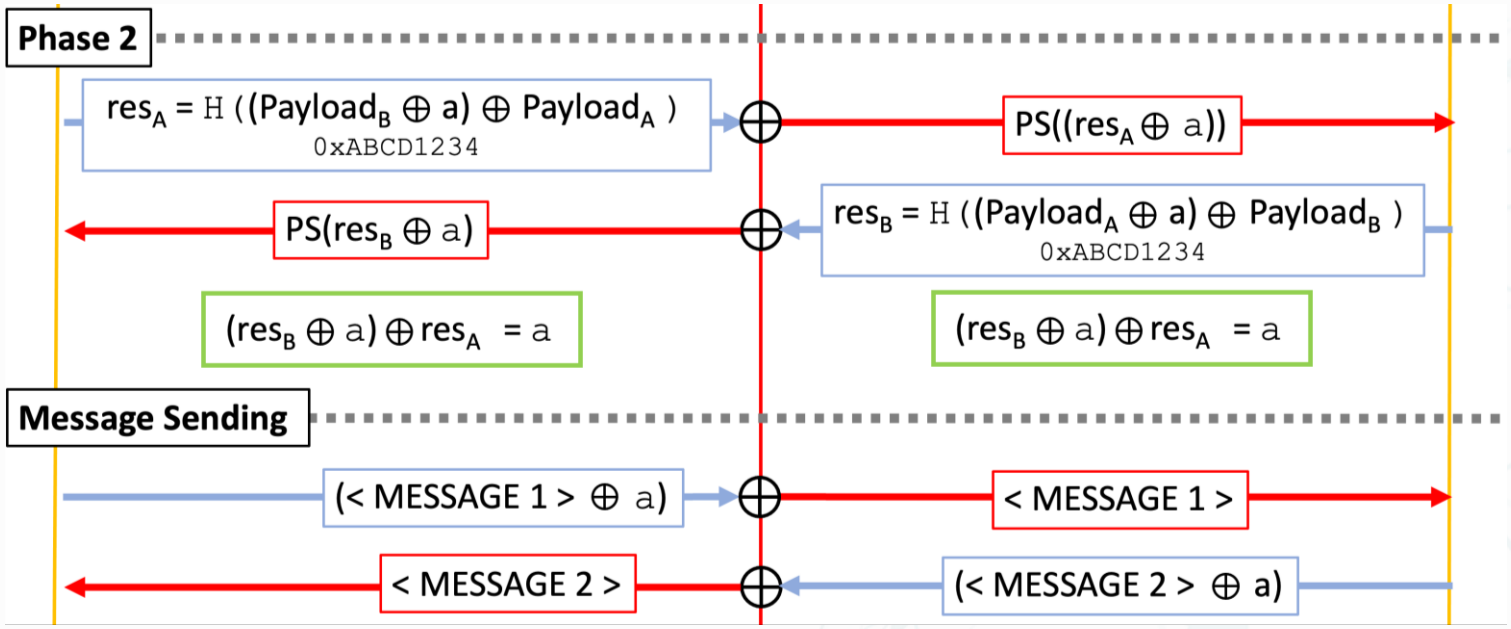


- Inverter are production related not identical
  → $V_{inversion} \neq V_M$
- Startup-Value is probabilistic
- „strongest“ inverter defines the state
- The further $V_{inversion}$ is removed form the bisecting angle the stronger the preference is

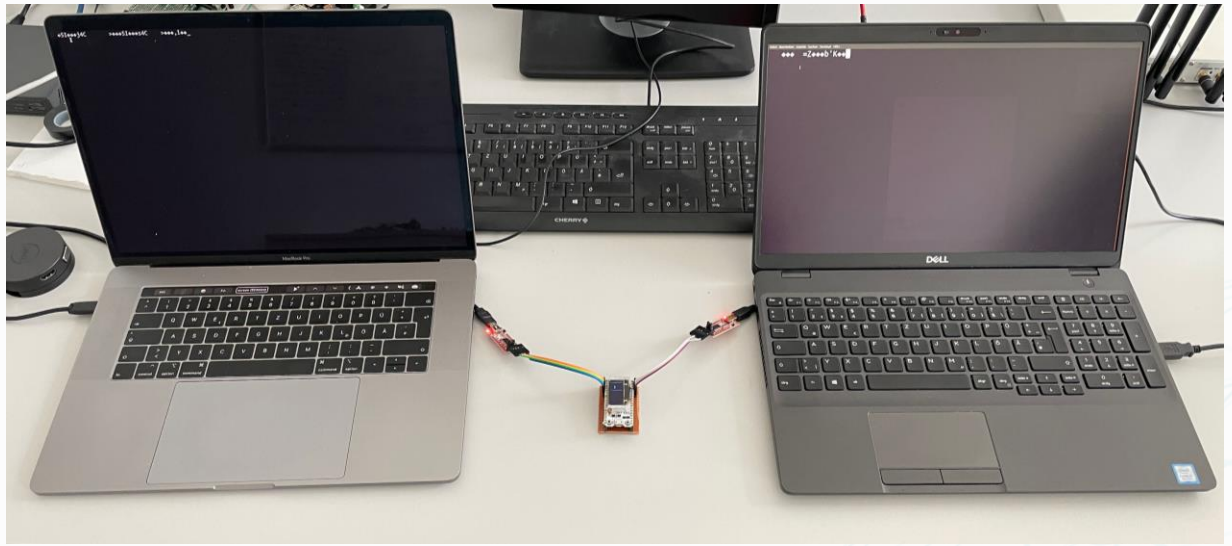
Wired Communication Scheme

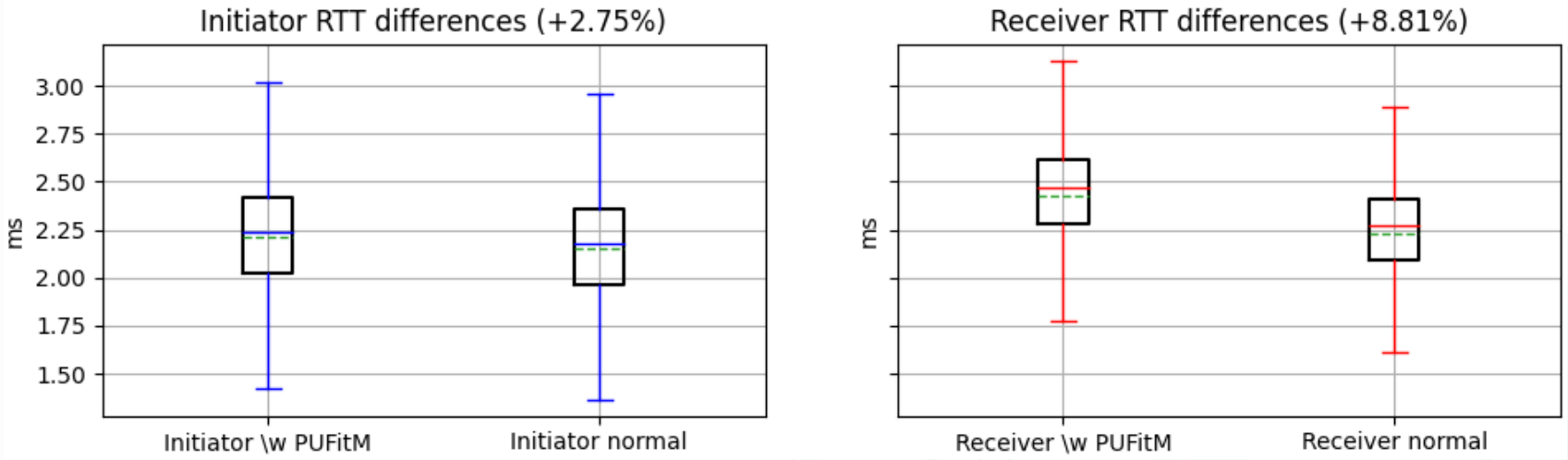


Wired Communication Scheme cont.

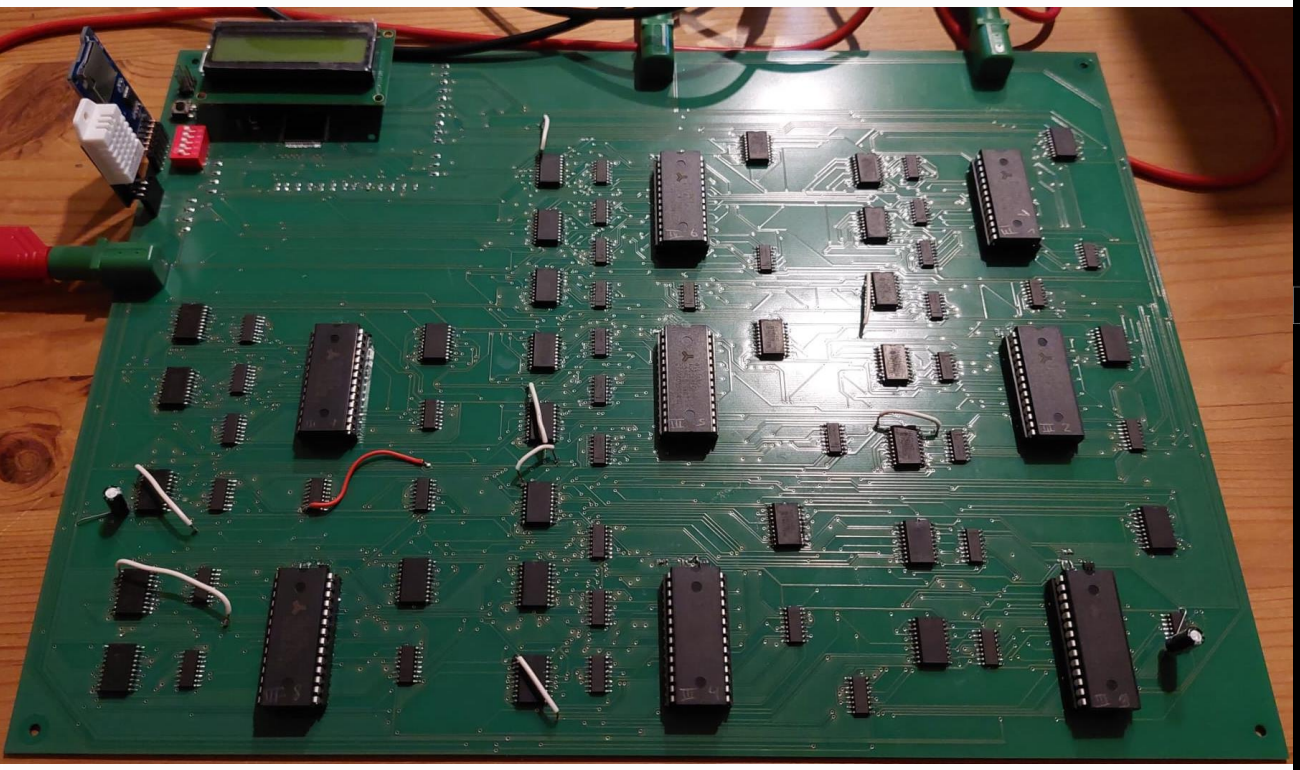


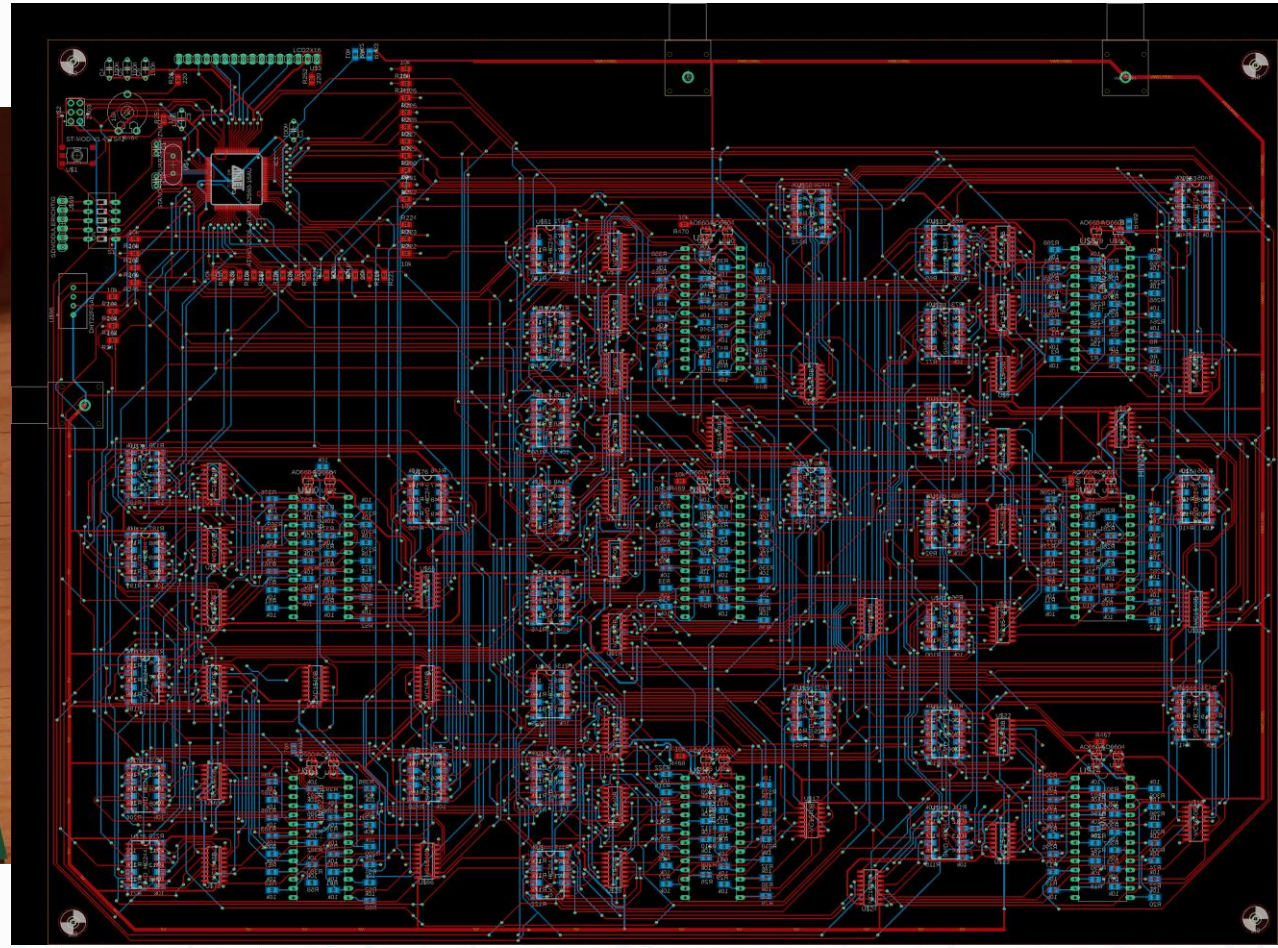
Experimental Setup





Supply Voltage Evaluation Platform



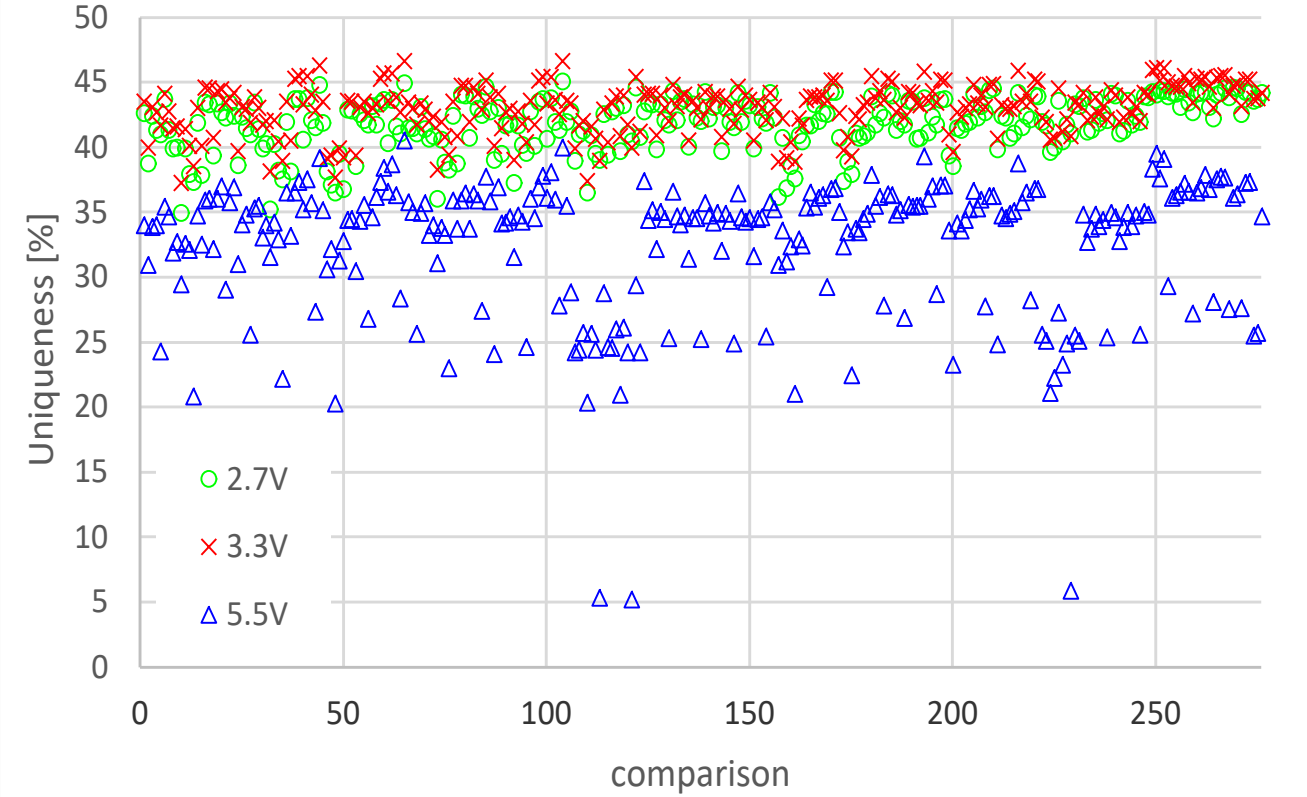


Uniqueness

$$\mathrm{HD}_{\mathrm{inter}} = \frac{2}{k \cdot (k-1)} \sum_{i=1}^{k-1} \sum_{j=i+1}^{k} \frac{\mathrm{HD}\left(R_i(n), R_j(n)\right)}{n} \cdot 100\%$$

- k: number of chips
- $R(n)$: n bit response
- HD: Hamming distance

- Best Value 50%



2.7V	3.3V	5.5V
41.81%	42.96%	32.56%

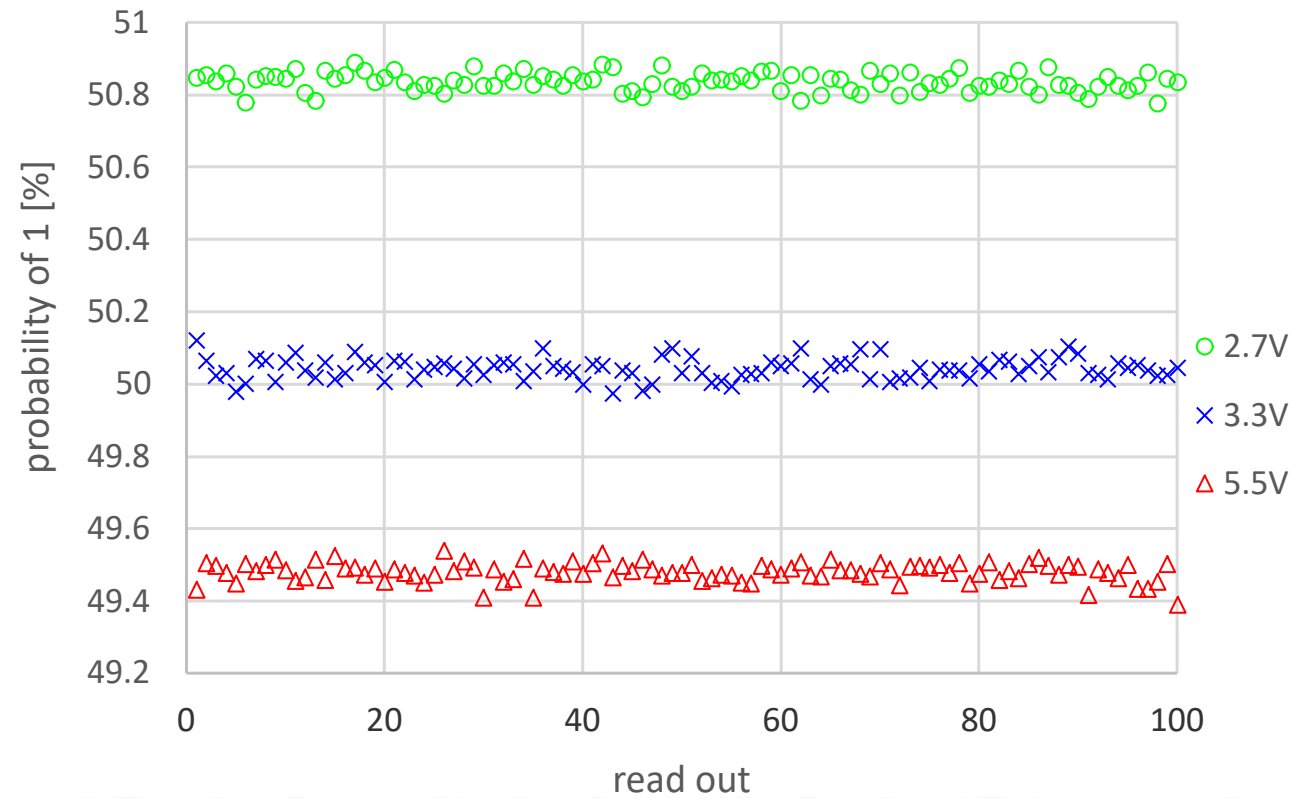
Uniformity

$$\text{Uniformity} = \frac{1}{k}\sum_{i=1}^{k} r_i \cdot 100\%$$

- k: number of responses of same chip
- r_i: Hamming Weight of response

- Best Value 50%

2.7V	3.3V	5.5V
49.95%	49.3%	48.84%



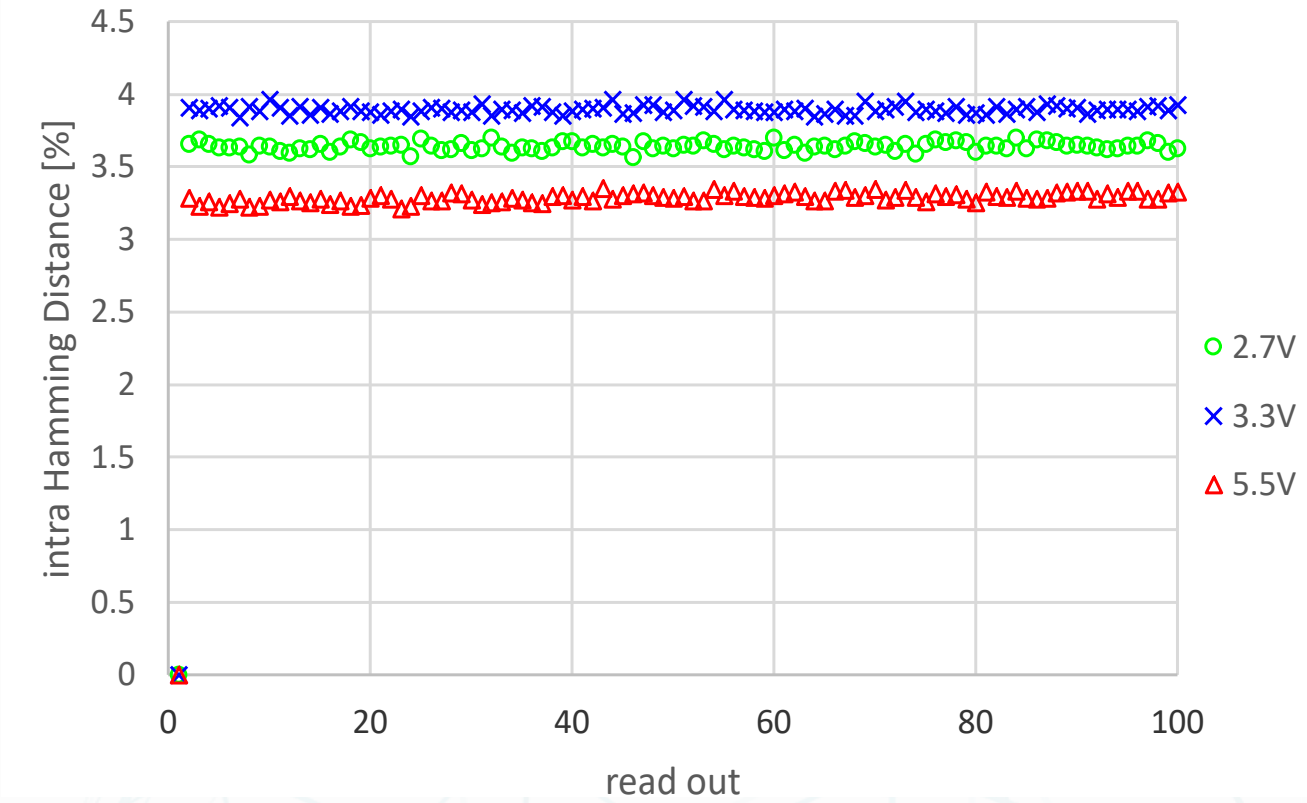
Reliability

$$100\% - \mathrm{HD}_{\mathrm{intra}} = \frac{1}{k}\sum_{i=1}^{k}\frac{\mathrm{HD}\left(R_i(n), R_i'(n)\right)}{n} \cdot 100\%$$

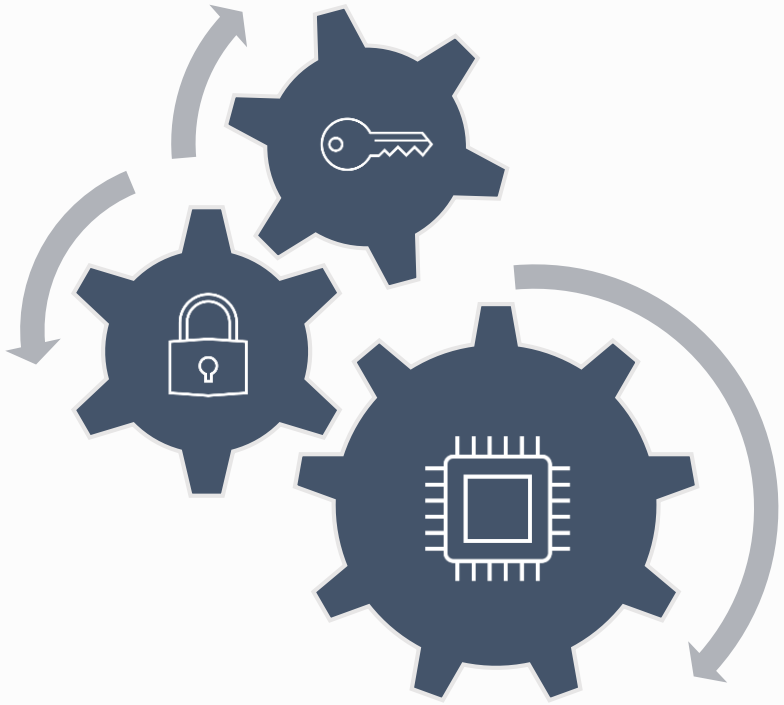
- k: number of chips
- $R(n)$: n bit response
- $R'(n)$: response at different condition
- HD: Hamming distance

- Best Value 100%

2.7V	3.3V	5.5V
96.15	96.03%	97.02%



Conclusion



- A new SRAM PUF based secure wired communication scheme
  - ➢ SRAM PUF as a source of entropy
- Successful real world implementation
  - ➢ Low overhead
- SRAM PUF is influenced by supply voltage variations
  - ➢ But still sound properties

THANK YOU

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