RUHR-UNIVERSITÄT BOCHUM

Side-Channel Leakage through Static Power

Should We Care about in Practice?

26. September 2014

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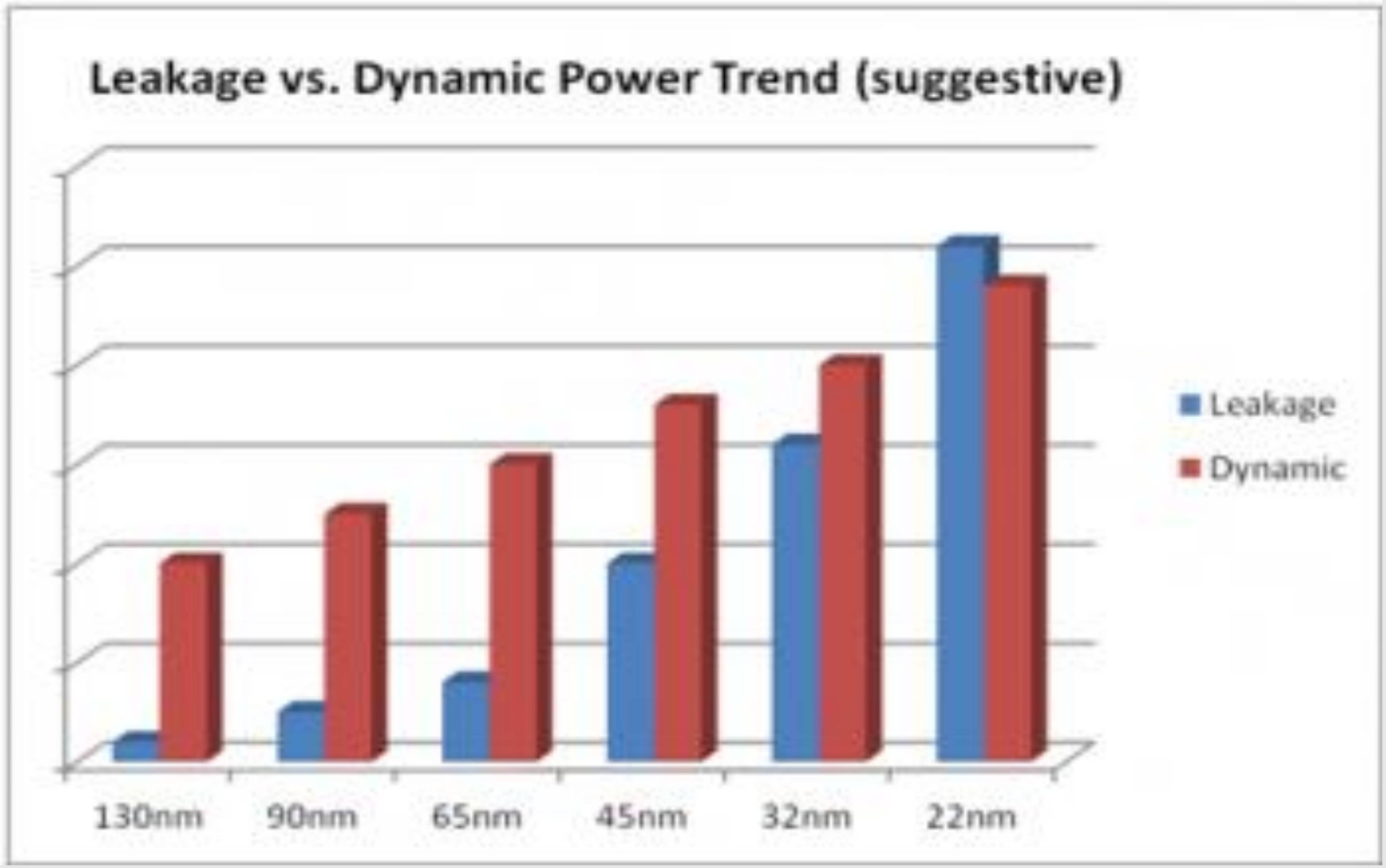
Dynamic vs. Static Power

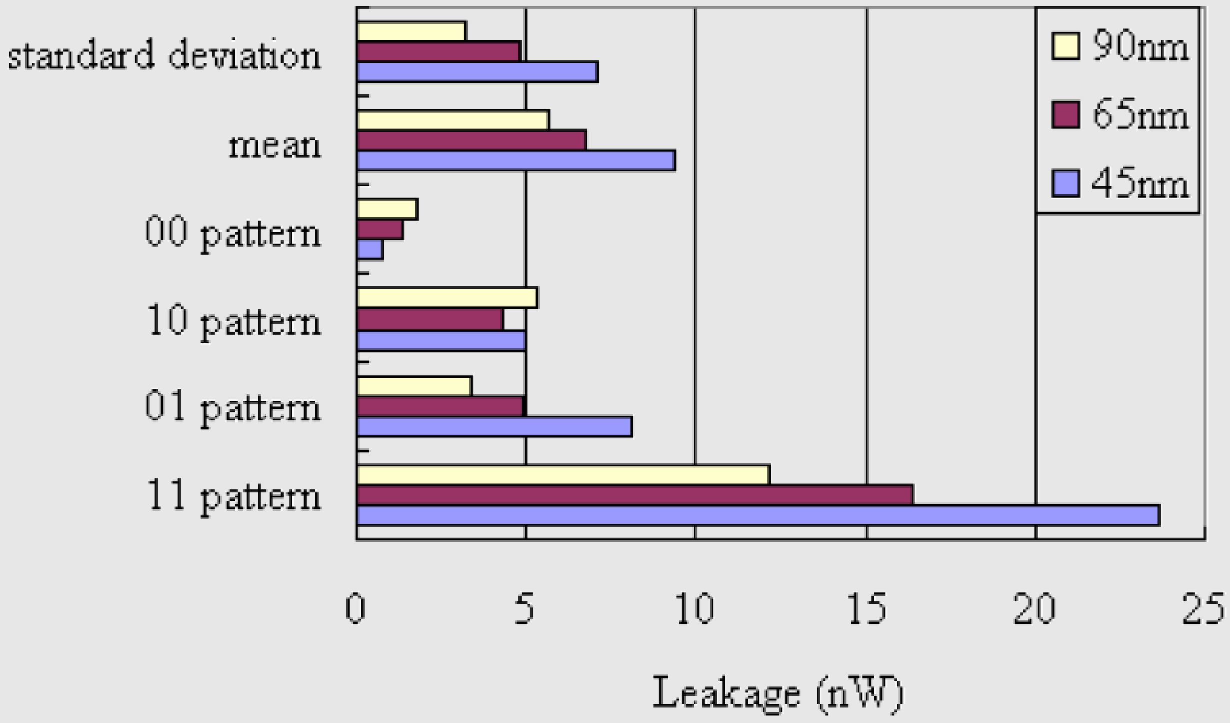


Dynamic vs. Static Power

- Dynamic power consumption
  - The main considered side channel (CMOS concept)
  - Easy to measure
  - Effective
  - …
- Static power consumption
  - becoming the major concern for VLSI community
  - introduced as a side channel by simulation results
  - also called *Leakage Power Analysis* (LPA)

What has been reported?

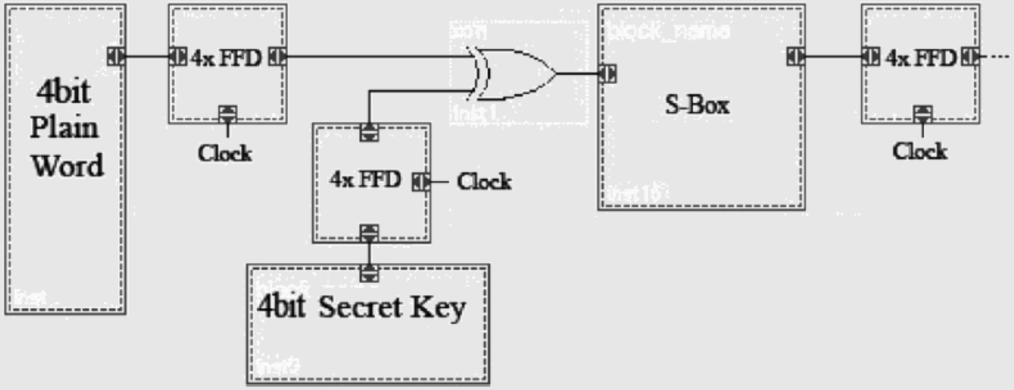
- Simulation results (2-input AND gate)

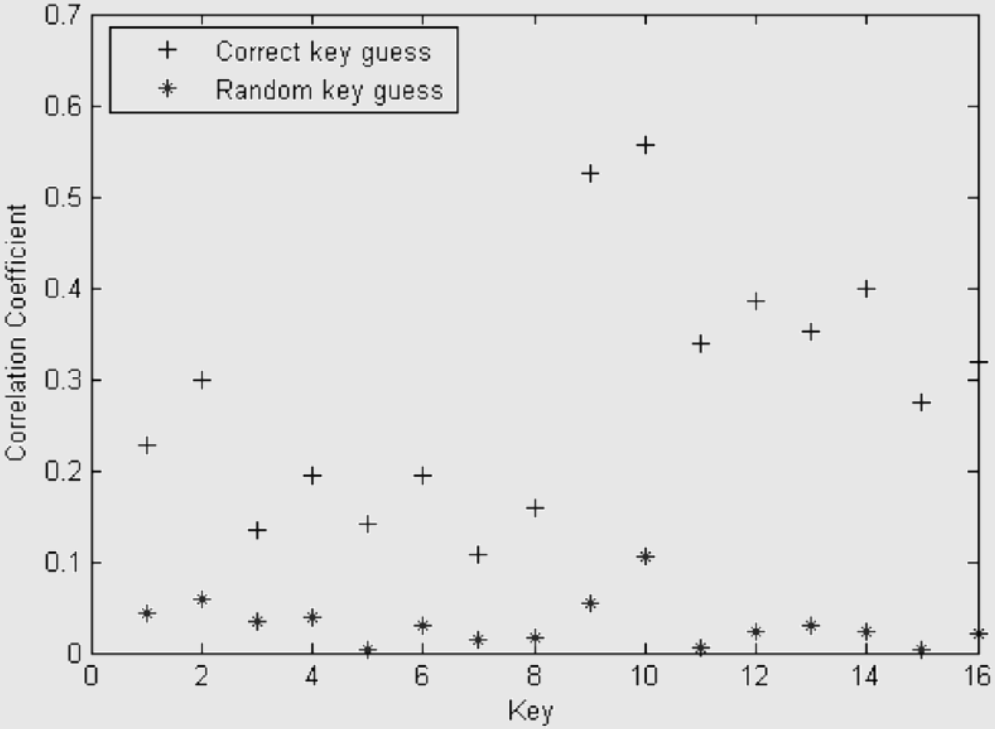


L. Lin and W. Burleson. Leakage-based differential power analysis (LDPA) on sub-90nm CMOS cryptosystems. ISCAS 2008.

What has been reported?

- Simulation results, Serpent Sbox

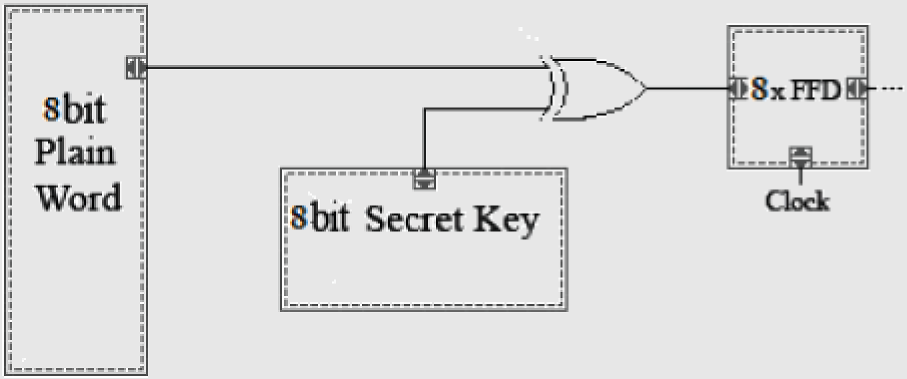


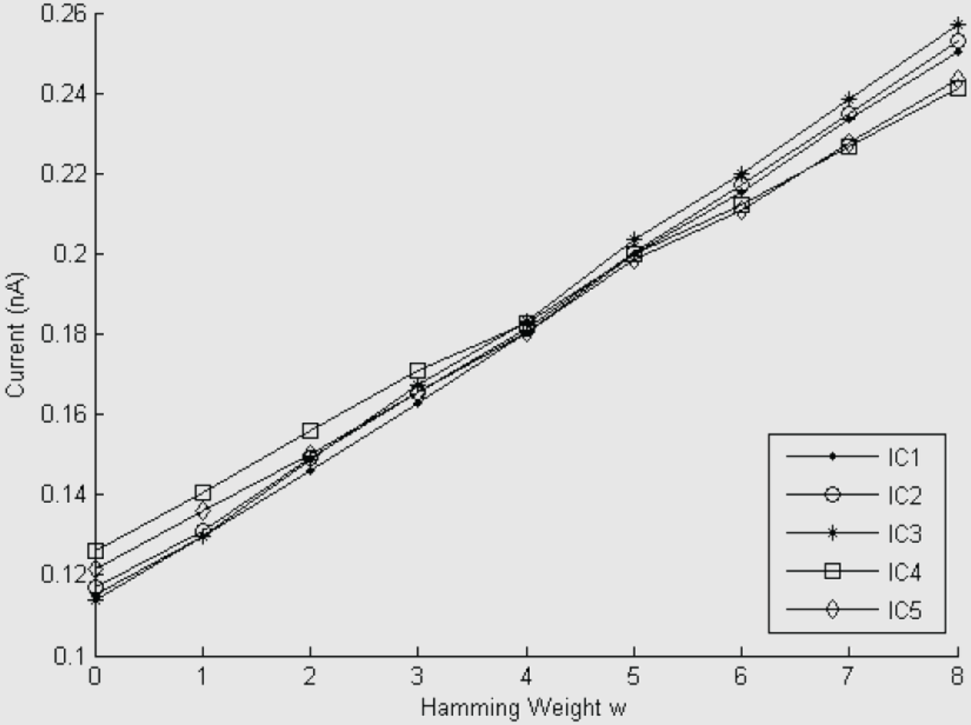


M. Alioto, L. Giancane, G. Scotti, and A. Trifiletti. Leakage Power Analysis Attacks: A Novel Class of Attacks to Nanometer Cryptographic Circuits. IEEE Trans. on Circuits and Systems, 2010.

What has been reported?

- Practical results (100 nm)





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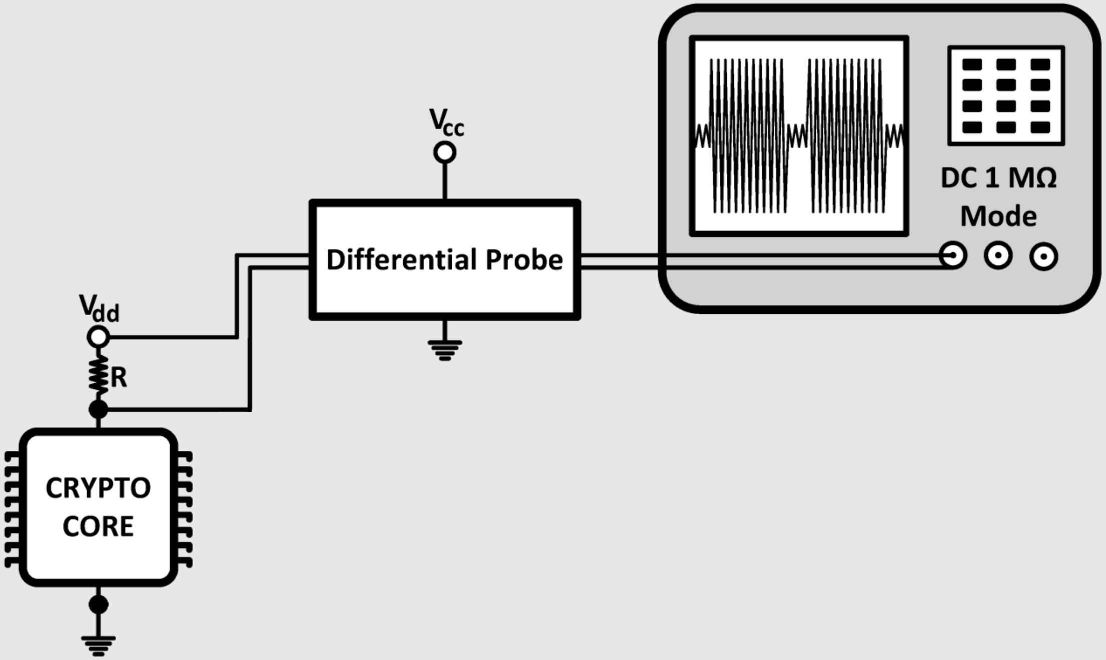
Measurement Setup (dynamic)



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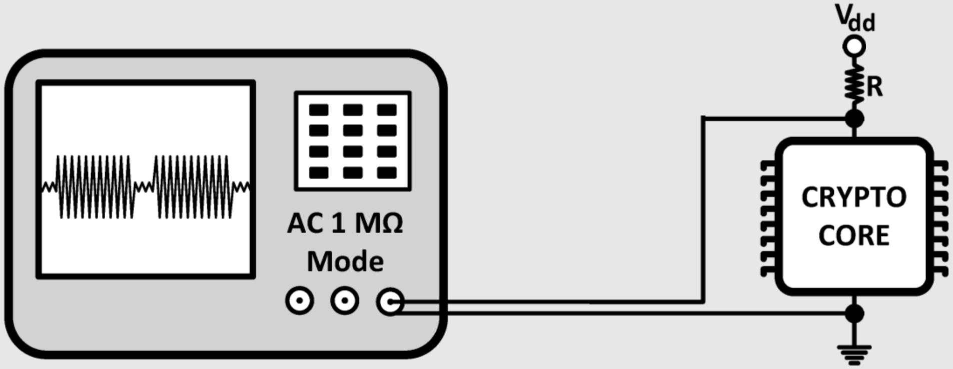

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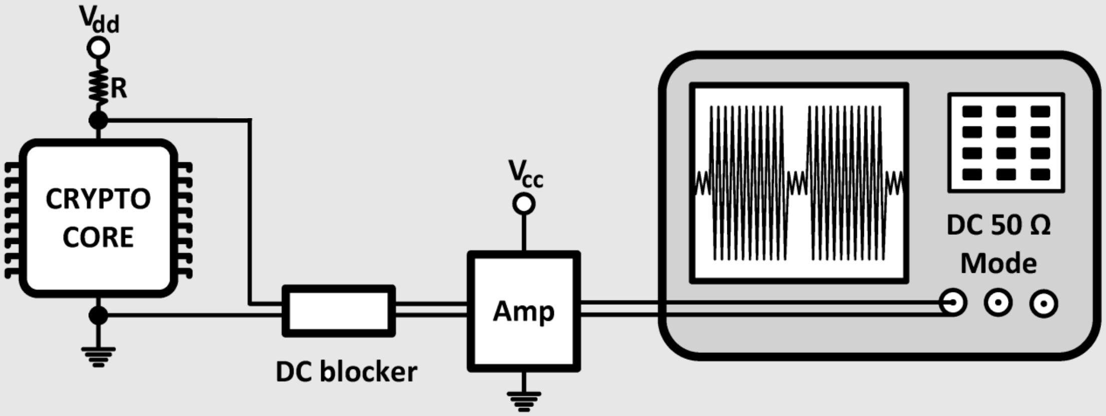

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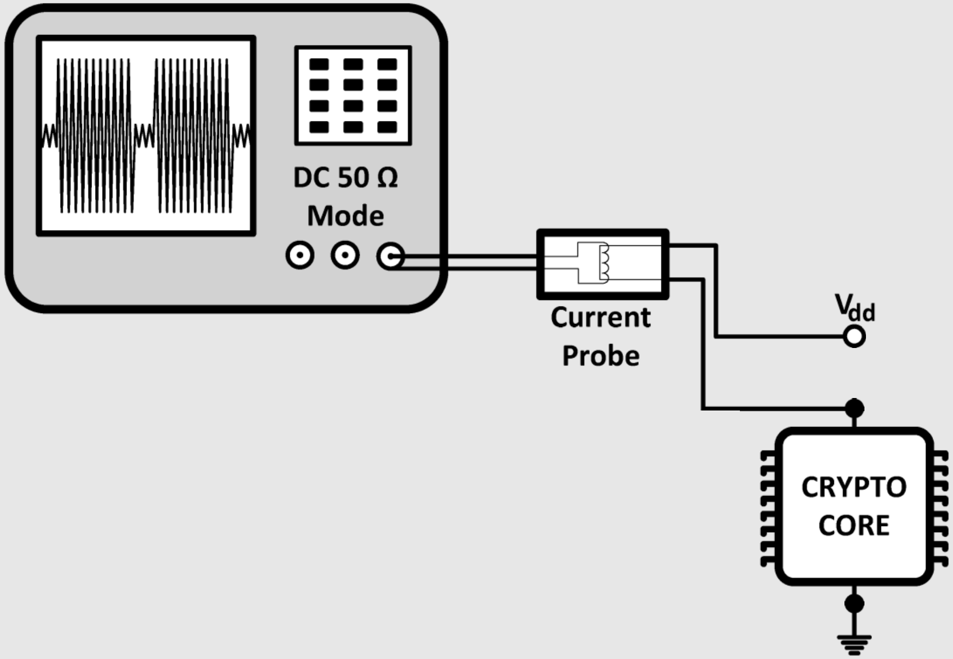

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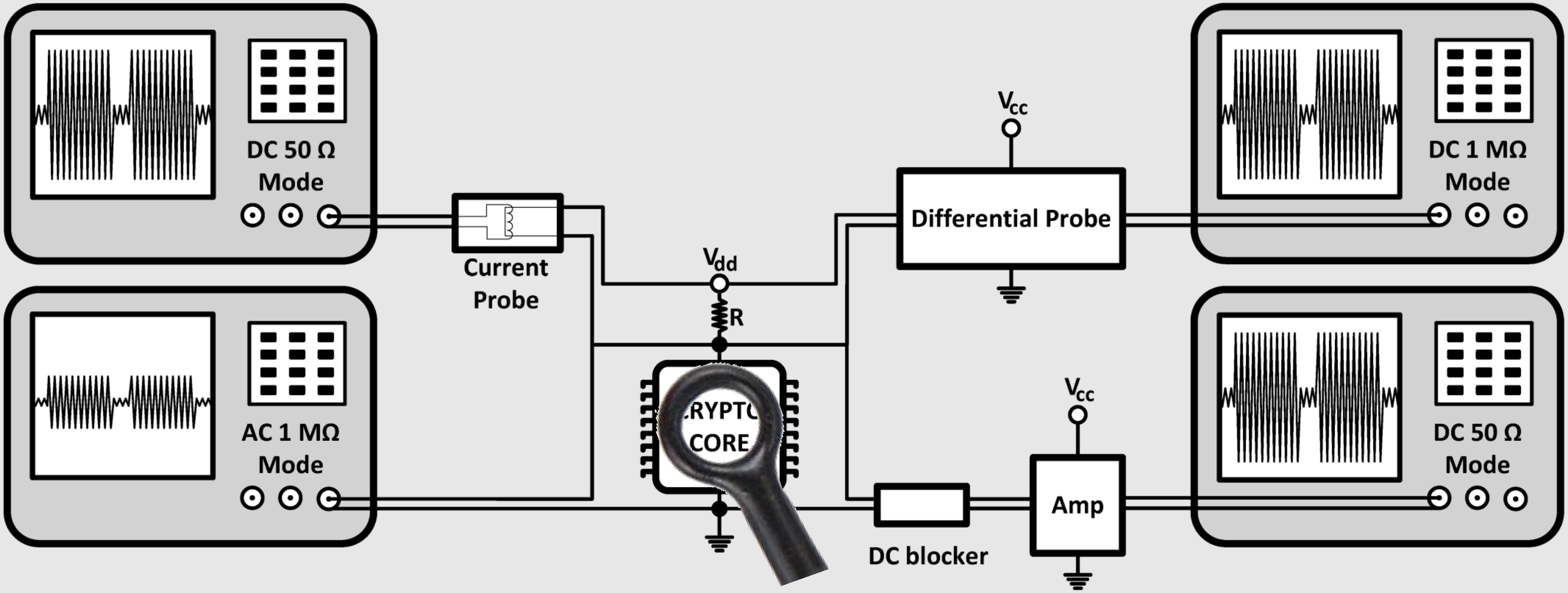
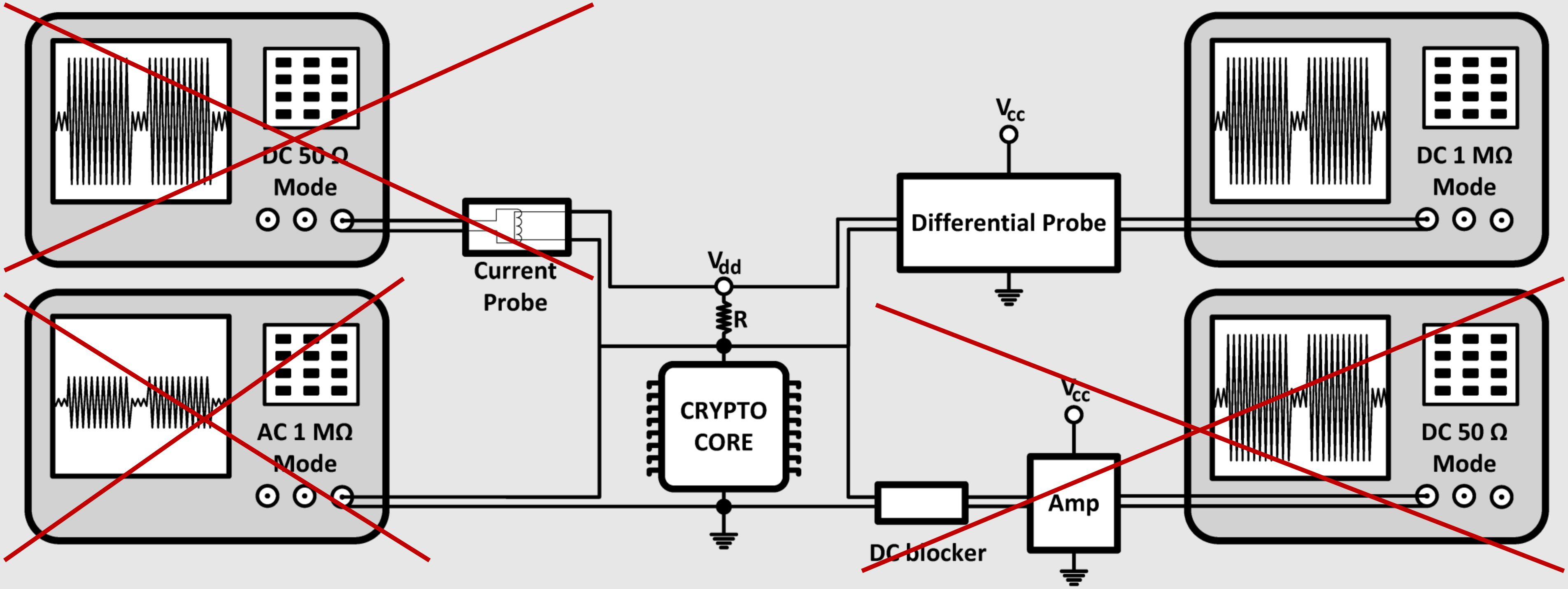


Measurement Setup (static)



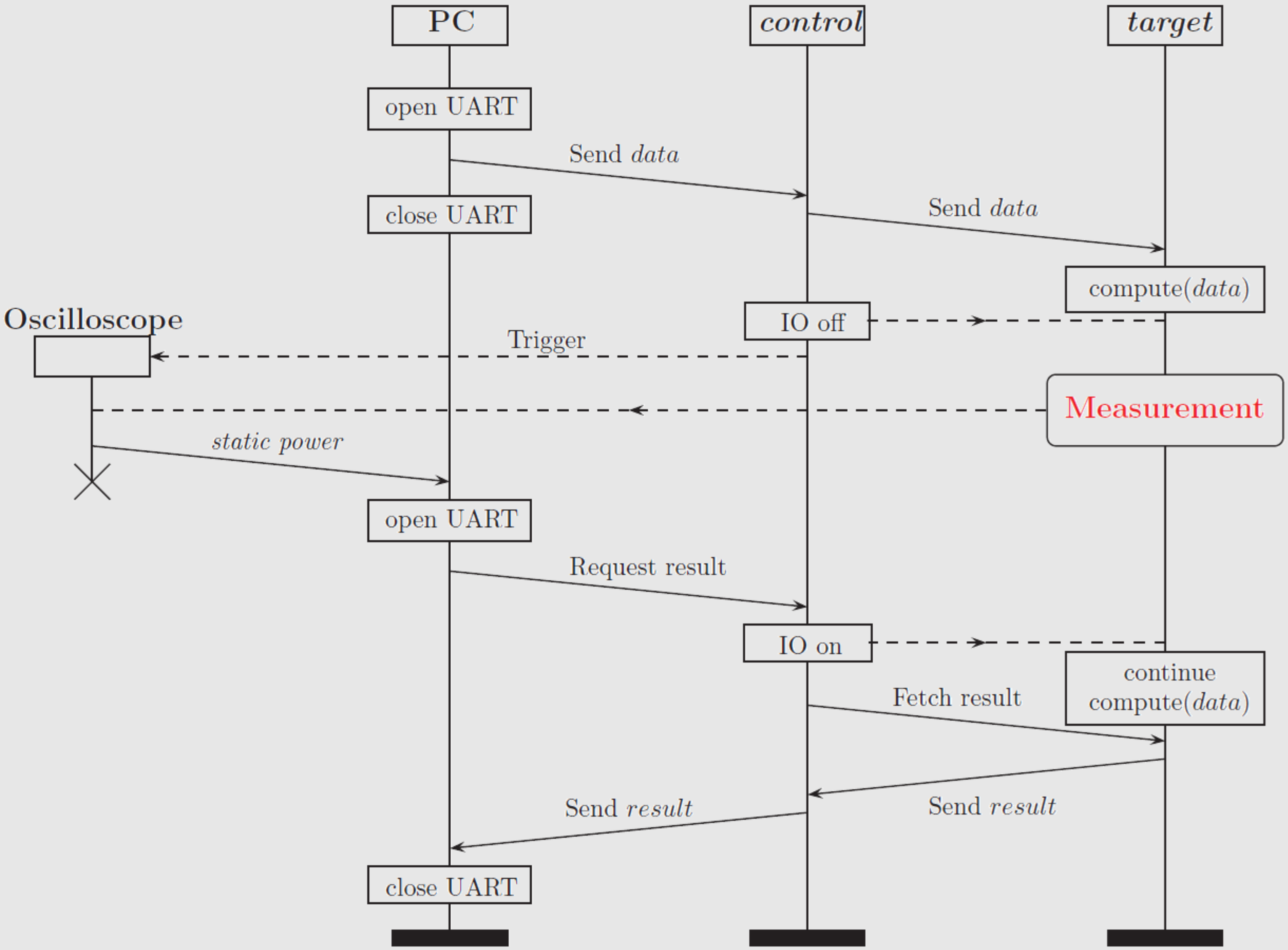
LeCroy AP 033

x10 internal amplifier

Targets

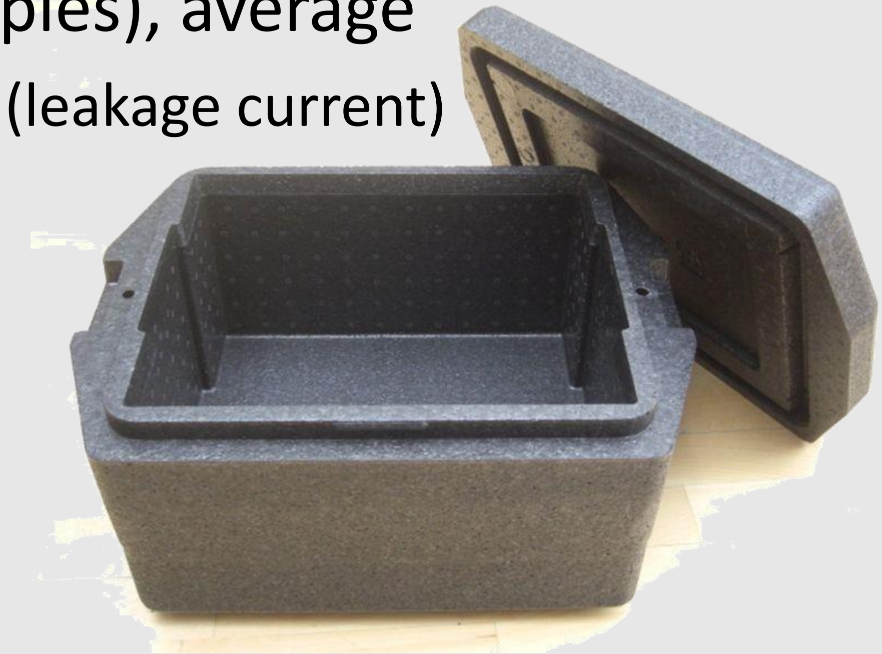
- SASEBO-GII, Virtex-5, 65nm
- SAKURA-G, Spartan-6, 45nm
- SAKURA-X, Kintex-7, 28nm

Measurement Methodology



Difficulties

- Highest vertical accuracy (200 µV/div)
- Noise
  - Sampling rate 1GS/s
  - 20MHz bandwidth limit
  - Long trace (10ms -> 10 M samples), average
    - A singular value as static power (leakage current)
- Super sensitive to temperature
  - Thermobox

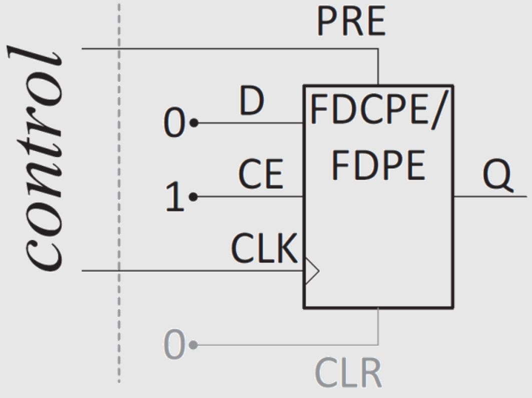


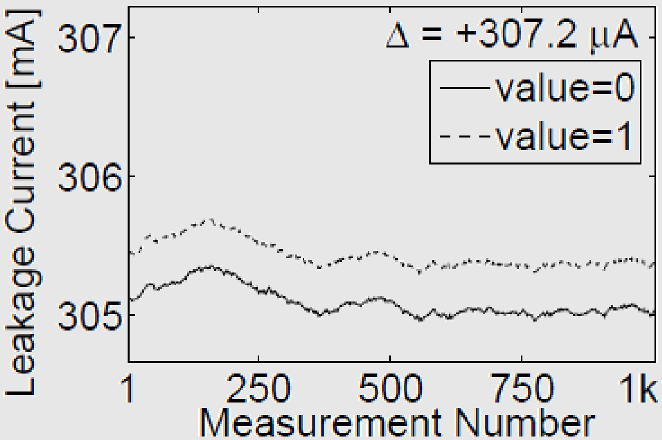
Preliminary Tests

- Contribution of Registers’ content
- Contribution of Connections (Switch Box)
- Contribution of Look-up tables (LUT)
- An AES Sbox
- A masked AES Sbox
- A masked shuffled AES encryption

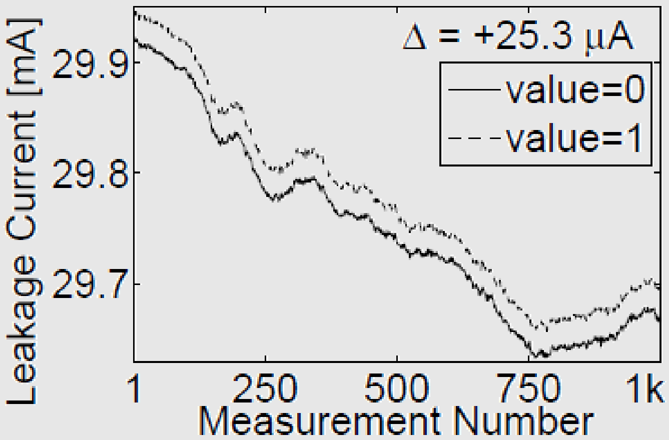
Preliminary Tests (Register)

- 14,400 registers
- The same measurement methodology for all targets

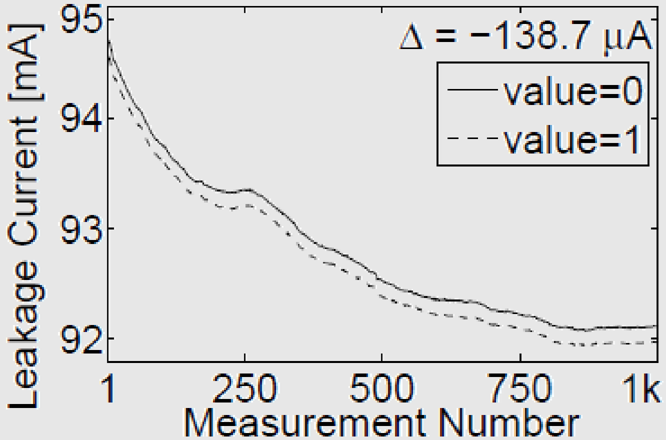




SASEBO-GII (Virtex-5)



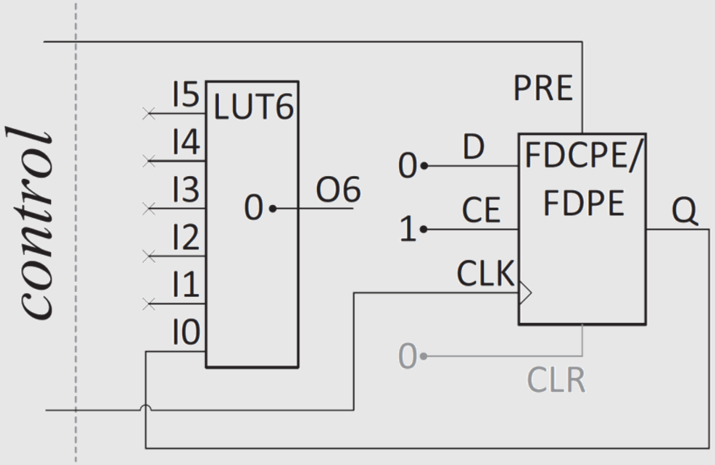
SAKURA-G (Spartan-6)

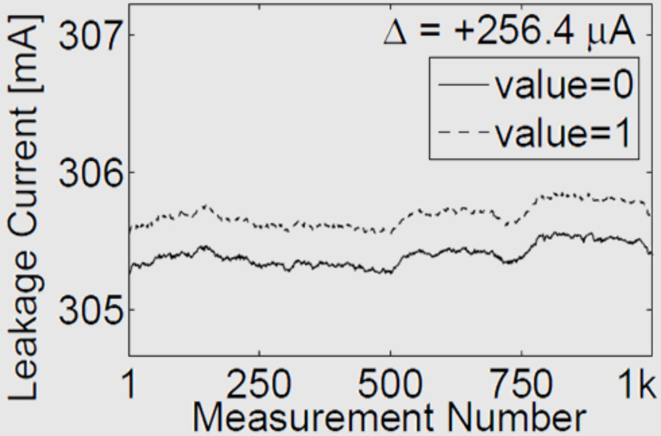


SAKURA-X (Kintex-7)

Preliminary Tests (Connection)

- 14,400 registers + Loop





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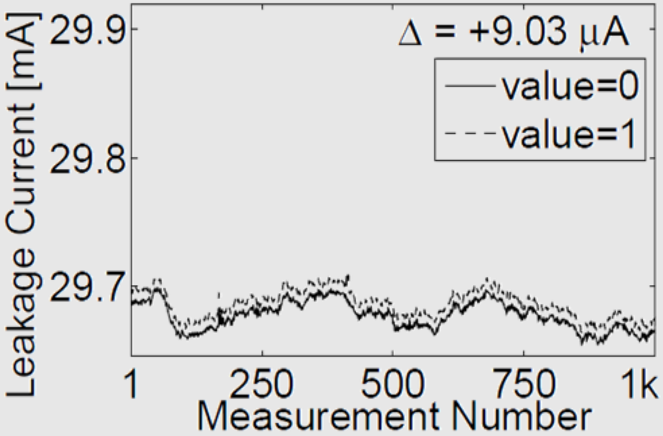

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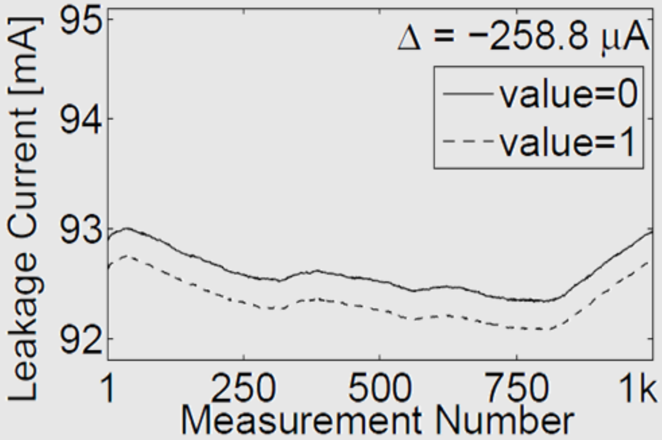
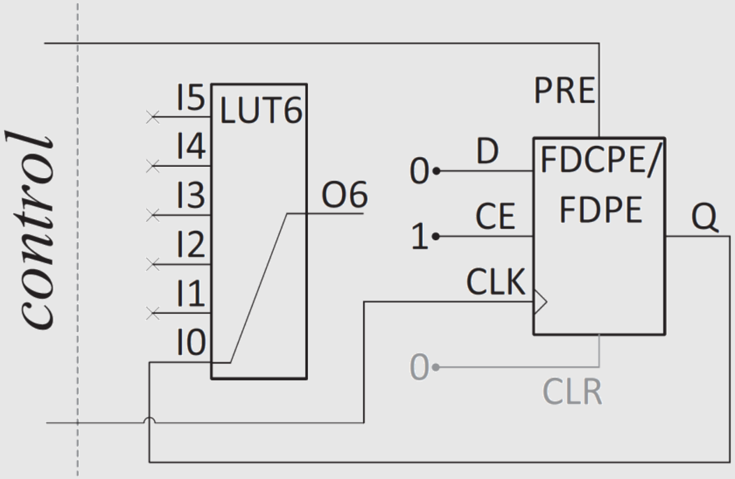
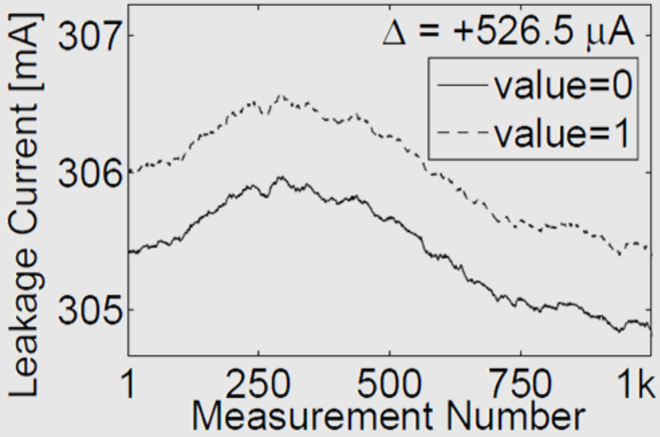


SAKURA-X (Kintex-7)

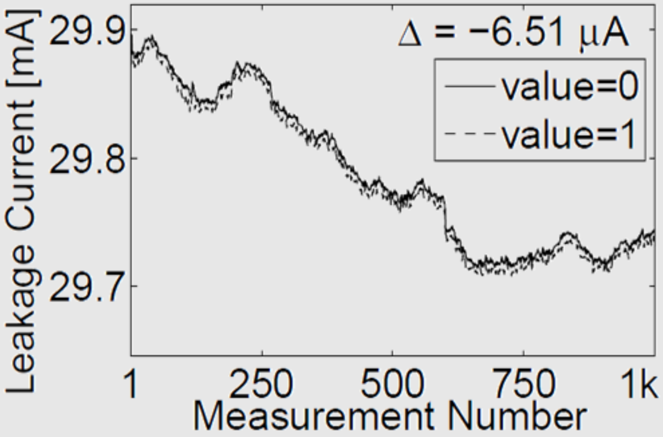
Preliminary Tests (LUT)

- 14,400 registers + Loop + LUT





SASEBO-GII (Virtex-5)



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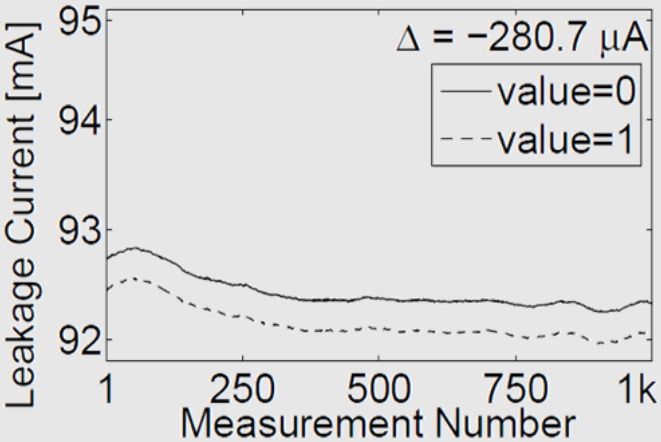
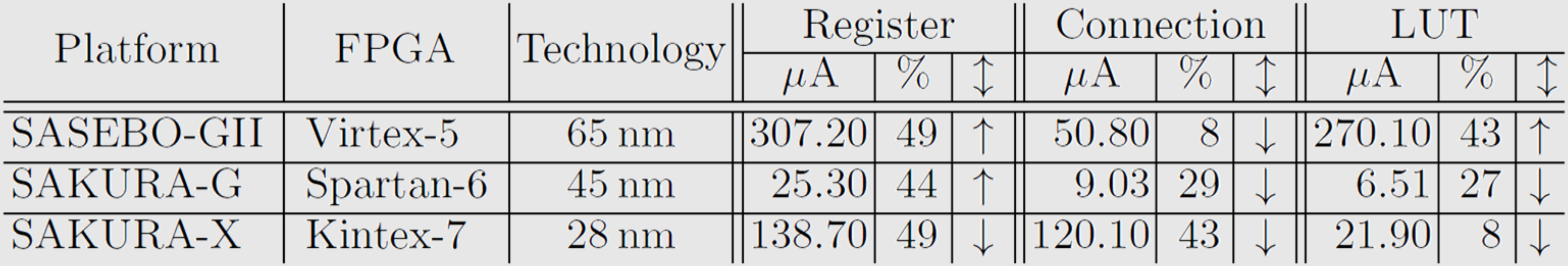


SAKURA-X (Kintex-7)

Preliminary Tests (summary)

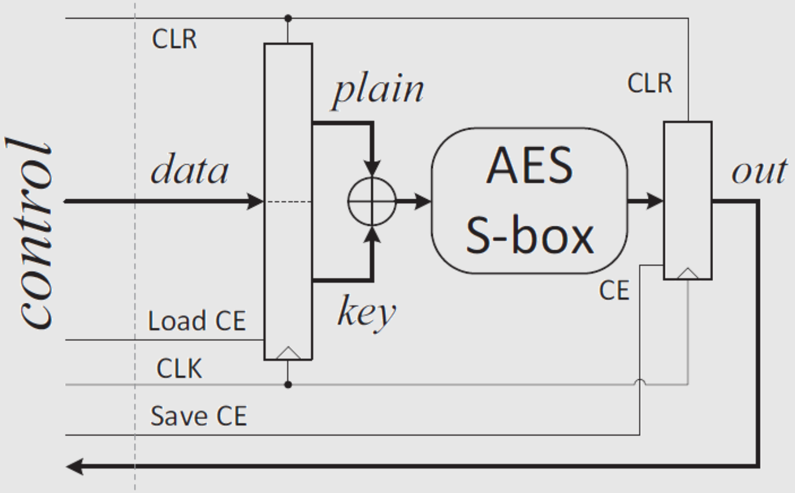


Platform	FPGA	Technology	Register			Connection			LUT		
			μA	%	↕	μA	%	↕	μA	%	↕
SASEBO-GII	Virtex-5	65 nm	307.20	49	↑	50.80	8	↓	270.10	43	↑
SAKURA-G	Spartan-6	45 nm	25.30	44	↑	9.03	29	↓	6.51	27	↓
SAKURA-X	Kintex-7	28 nm	138.70	49	↓	120.10	43	↓	21.90	8	↓

- Temperature of the tests/devices was not the same
  – results vary by slight temperature change

Preliminary Tests (Sbox)

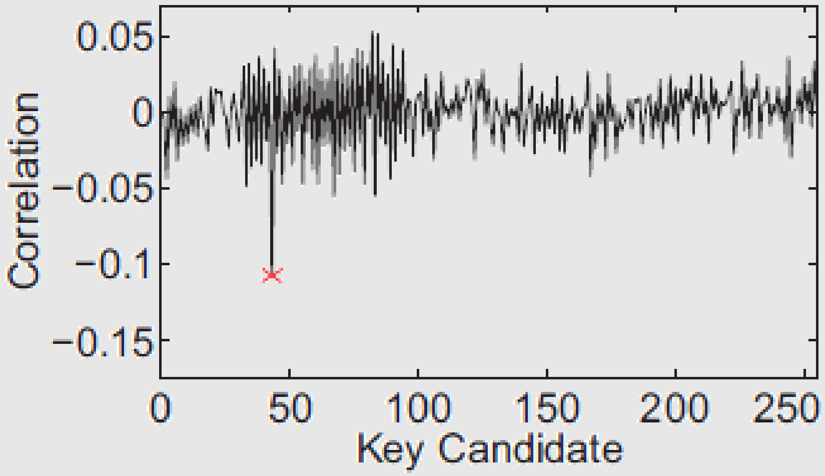
- Single Key XOR + AES Sbox
- Canright’s design
- SAKURA-X (Kintex-7)



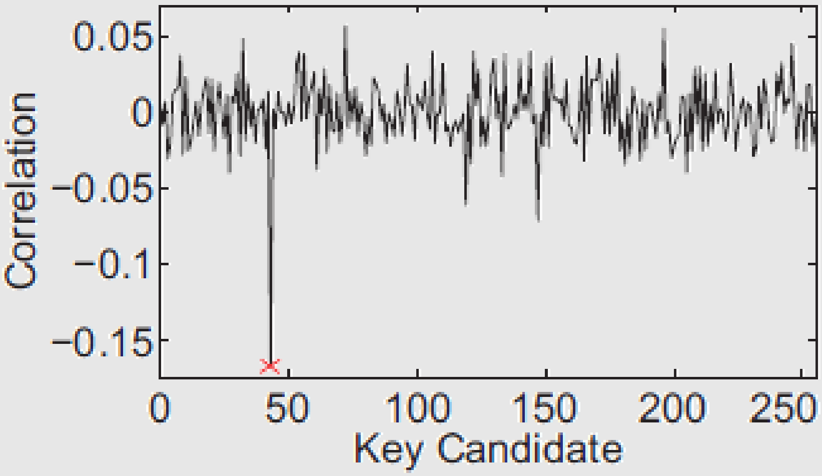
- Due to temperature change
  - Two consecutive measurements of RESET and DATA
  - L_{DATA}-L_{RESET} as the leakage corresponding to DATA
- Measure right before saving the Sbox output in register
- Two placements for Sbox and output registers distance

Preliminary Tests (Sbox)

- 10,000 measurements for a single key and random input
- CPA by Hamming weight model (Sbox output)
  - not a necessarily perfect model
    - depends on placement and routing
  - better model by e.g., profiling (moments-correlating DPA)



Normal Placement



Wide Placement

Issues

- Main energy-consuming component: connections in FPGAs
  - not the same in case of ASICs
- Dedicated measurement setup
  - low-noise ***DC*** amplifier
  - ability to control the CLOCK
    - Many other attacks, e.g., fault attacks, are possible
- Appropriate box to precisely control the temperature
  - not a thermobox
- Information about the device under attack is required
  - e.g., which clock cycle to stop the CLOCK and measure
- Longer measurement procedure vs. dynamic
- Lower SNR compared to dynamic

Final Message

- Static power side-channel analysis is possible, but
  - shown results are preliminary
  - more research in this area needed
    - dedicated measurement setup
    - in which scenarios it is favorable than dynamic one?
    - what is the behavior of the commonly-known countermeasures?
    - how well the results match with those of an ASIC?

Thanks!
Any questions?

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