Analysis of Side-Channel Attacks on RFID/NFC Devices

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Goal

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Analyze the feasibility of **remote** electromagnetic side-channel attacks against RFID/NFC tags.

RFID Side-Channel Attacks

RFID

Radio Frequency IDentification

Wireless communication technology that uses a powered reader that provides energy, information, and a communication channel to a passive (i.e., powerless) tag using an EM field.

RFID Side-Channel Attack

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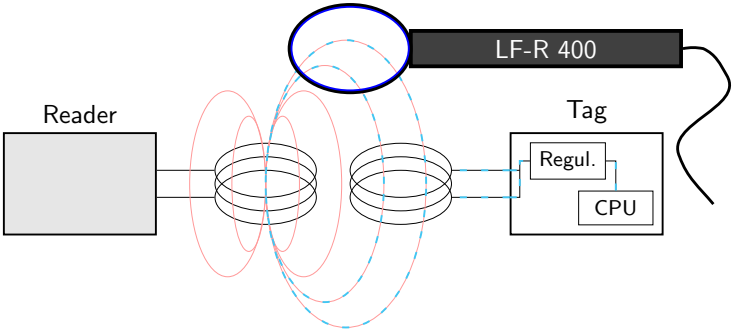
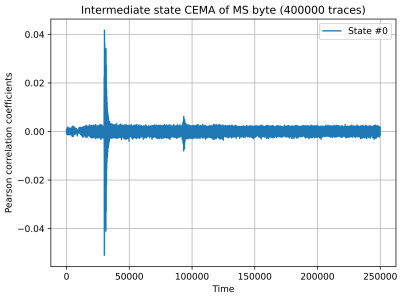
To do so, we measure the field of the EM coupling:



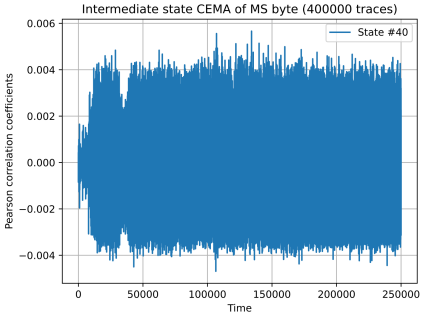
Attacks

Input and Output Correlation

We run a correlation analysis with the input and output:



(a) Input



(b) Output

Figure: Input and Output CEMA (20M traces).

Intermediate State Correlation

Similarly with an appropriate intermediate state:

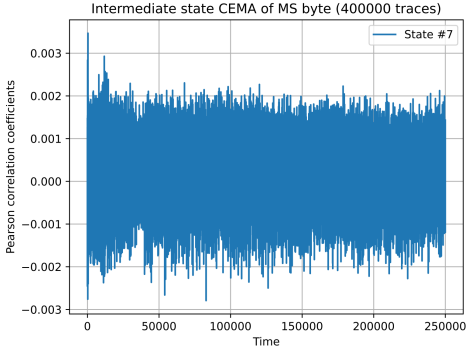


Figure: Intermediate state CEMA (20M traces)

Lack of Correlation

Why?

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$\rightarrow$ Best way to find out: study the bare electromagnetic signal using analog demodulation.

Envelope Detector Implementation

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We tried multiple solutions to implement an envelope detector:

- Software Defined Radio
  → Complex demodulation is hard to implement
- Analog circuitry
  → Careful implementation and optimization is required
- RFID Reader
  → Only ASK (de)modulation is done by the frontend

Vertical Peak Focus

Zoom to focus on the variations of the carrier signal caused by modulation.

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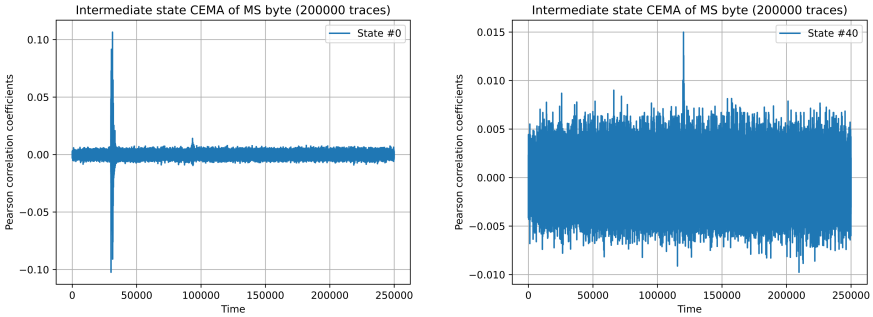

(a) Input

(b) Output

Figure: Input and output CEMA (12.5M traces).

Vertical Peak Focus

For the intermediate state CEMA on the traces with vertical peak focus.

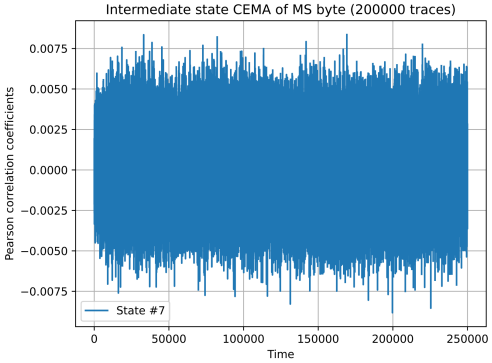

Figure: Intermediate State CEMA (12.5M traces).

Machine-Learning Side-Channel Attack

Machine learning is commonly used for side-channel attacks as it show good result. The goal is to build a classifier to recover the subkeys.

Fix vs Random Classifier

We used multiple classifiers to determine if a trace is fixed or random. We get very good result:

74.9%	25.1%
27.5%	72.5%

(a) Logistic regression.

73.6%	26.4%
30.6%	69.4%

(b) Linear SVM.

87.7%	12.3%
12.3%	87.7%

(c) MLP.

This reinforces the idea that we might have key-related leakage.

Fix vs Fix Classifier

Similarly, we built a fix vs fix classifier. We again get very good result:

62.6%	37.4%
42.3%	57.7%

(a) Linear SVM.

79.9%	20.3%
21.4%	78.6%

(b) MLP.

We do have full-key leakage!

Sub-Key Classifier

We need to be able to classify traces according to a subkey (e.g., 2^8 classes).
$\rightarrow$ The byte key classifiers did not however show good results...

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Possibly a key-dependent mask preventing byte-level analysis.
$\rightarrow$ Key-dependent leakage, but no sub-key dependent leakage

Future Works

- Higher-order side-channel attack
  $\rightarrow$ Requires insight and much smaller time frames

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- Higher-order side-channel attack
  $\rightarrow$ Requires insight and much smaller time frames
- Microscopic probe insight
  $\rightarrow$ An attacker could use it to do the whole attack

Thank you!