Power Analysis Part IV

Cryptographic Hardware for Embedded Systems ECE 3170

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Reading

- This rest of this lecture covers a portion of Differential Power Analysis as explained in Chapter 1 of *Power Analysis Attacks: Revealing the Secrets of Smart Cards* by Mangard et al., 2007, ISBN-13: 978-0-387-30857-9, ISBN-10: 0-387-30857-1, e-ISBN-10: 0-387-38162-7.

AES Power Trace

- Flat first 0.35 ms
- After receiving plaintext input at 0.35 ms, nine AES rounds occur
  - Each round appears to take 0.4 ms
- Final AES round (round 10) omits MixColumns
- At approximately 4.1 ms the microcontroller waits again
- 10 MHz ⇒ 0.1 µs (100ns) per instr ⇒ 1000 instructions in 0.1ms

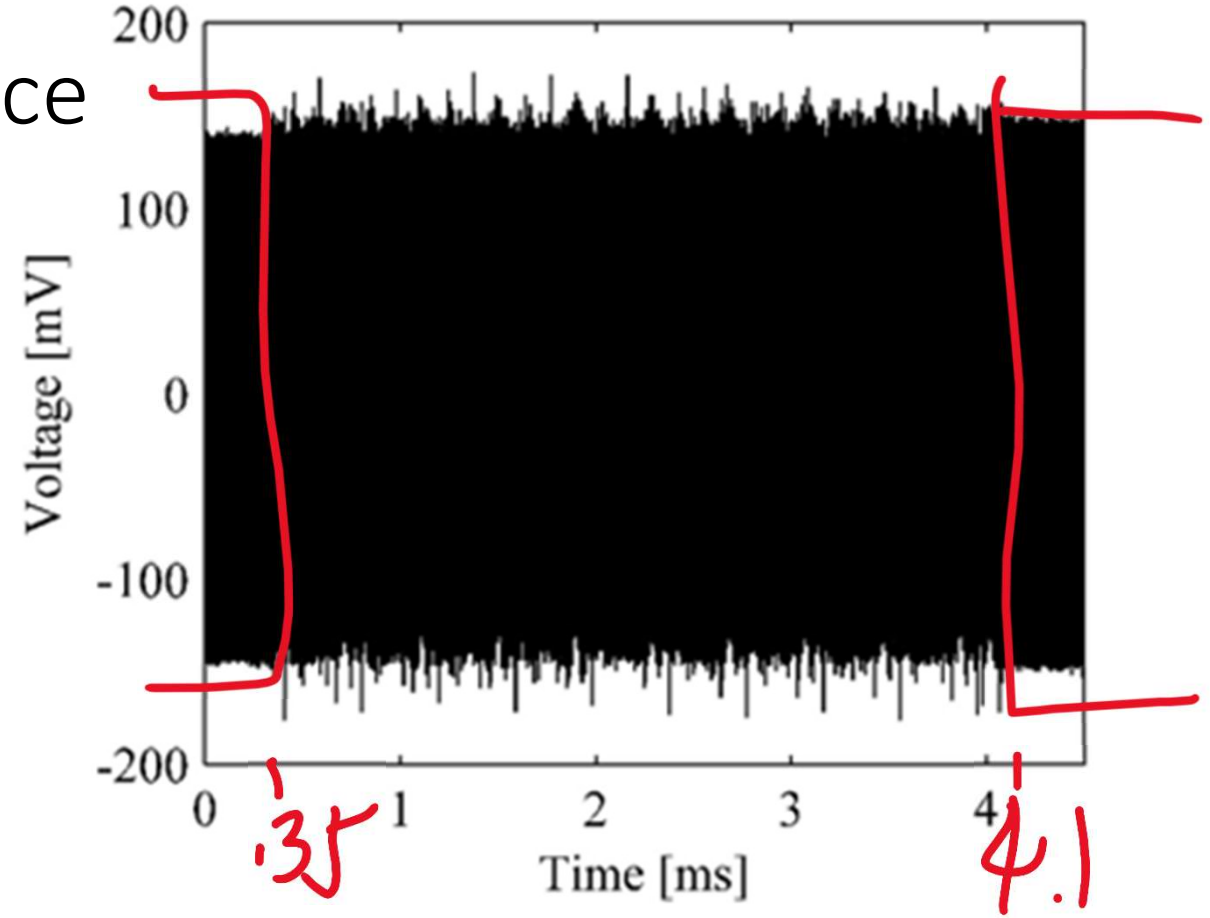
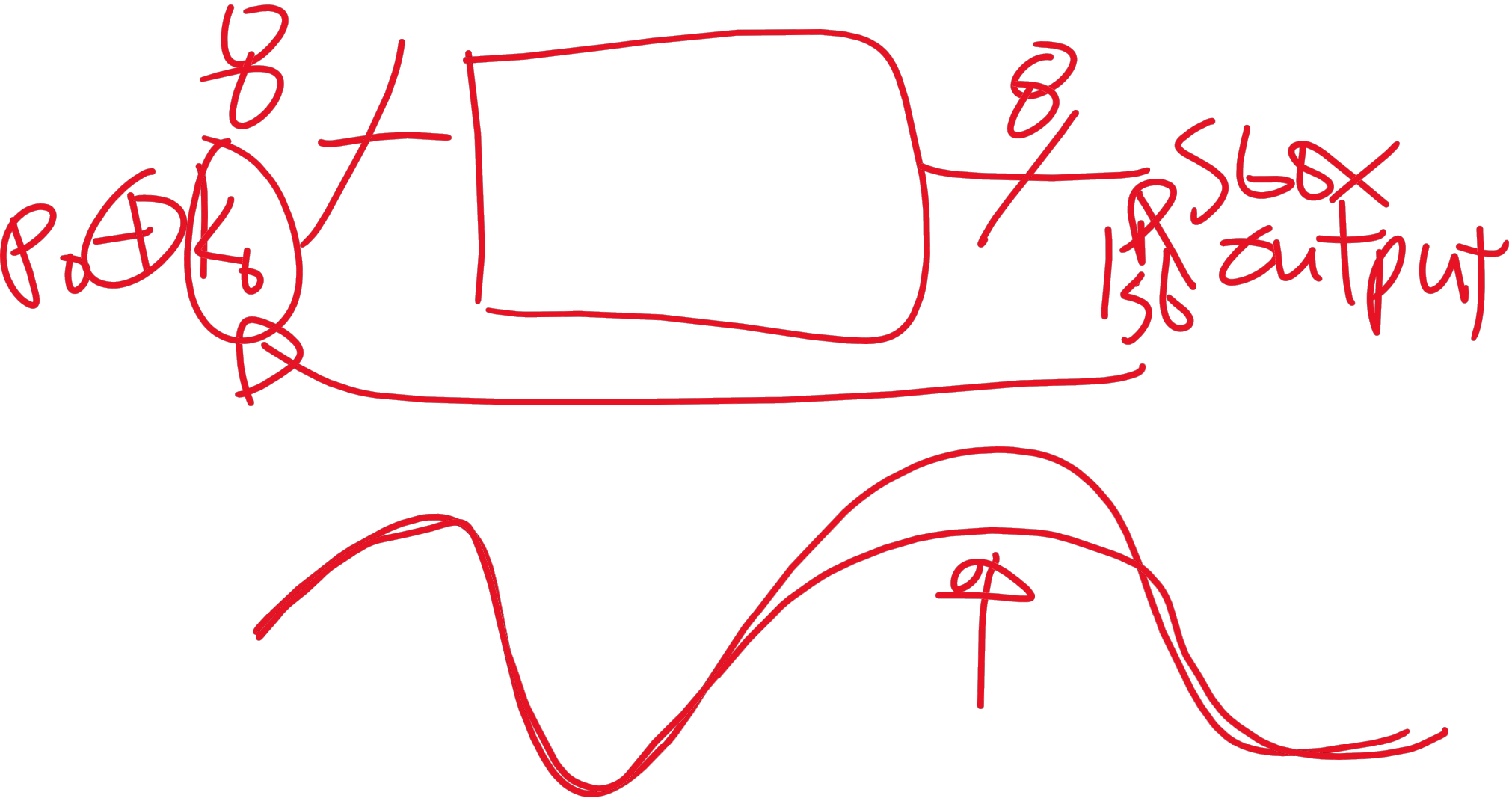


Figure 1.1. The voltage drop (power consumption) of the microcontroller while it performs an AES encryption.



Difference of Mean Power

- Consider MSB of plaintext 1st byte
  - *d*
- Measure 1000 traces: ½ with *d*=1, ½ with *d*=0
- Calculate difference of means
- Peaks indicate dependence on value of *d*

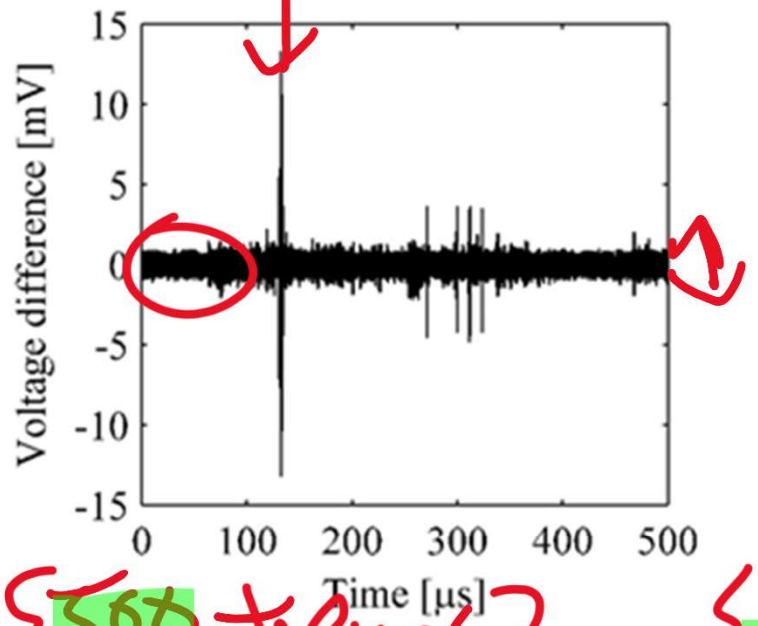


Figure 1.3. Difference of the mean power trace for $d = 1$ and the mean power trace for $d = 0$.

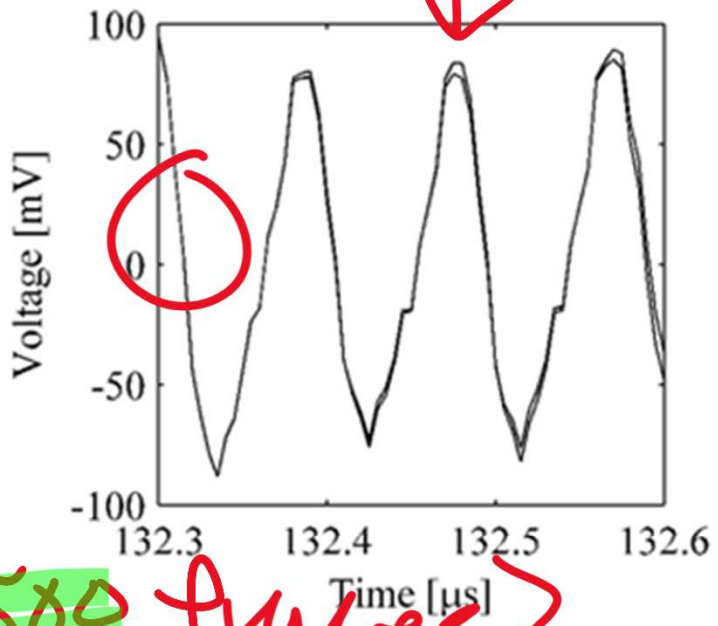


Figure 1.4. Zoomed view of the mean power trace for $d = 1$ and the mean power trace for $d = 0$.

Instruction Dependence on bit *d*

- AES S-box operation *S()* "SubBytes"
- Let *p* = first plaintext bye, *k* = first key byte
- Fig. 1.4 shows mean power traces for calc. $S(p \oplus k)$

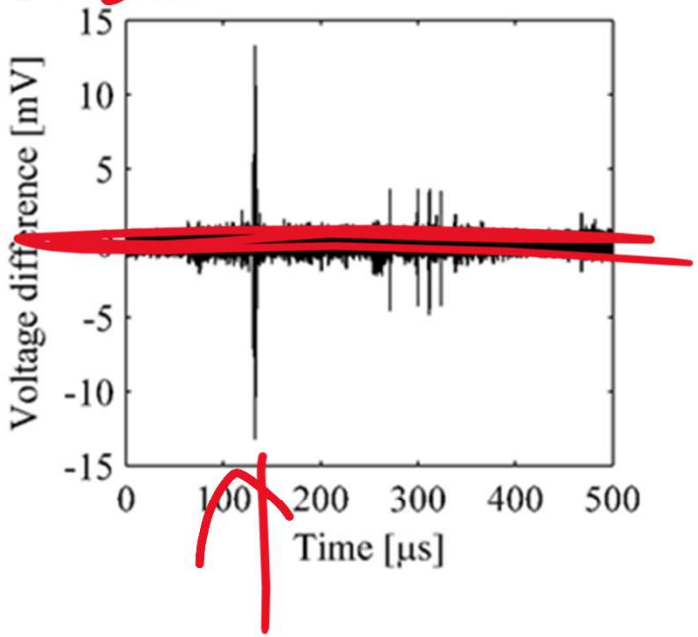


Figure 1.3. Difference of the mean power trace for $d = 1$ and the mean power trace for $d = 0$.

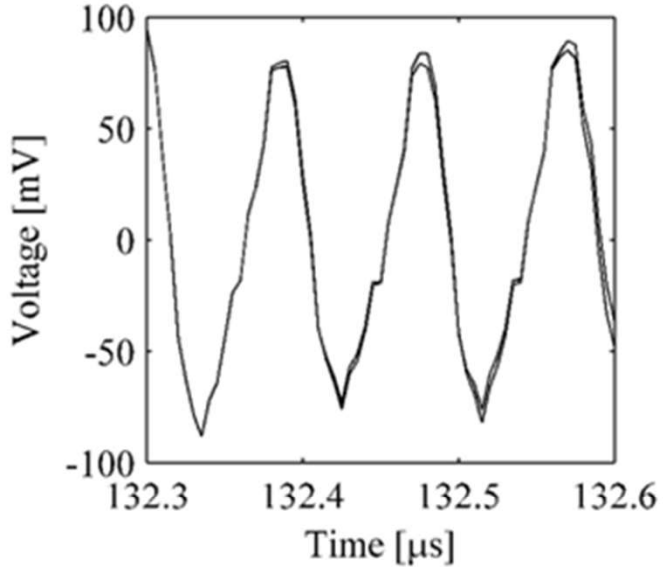


Figure 1.4. Zoomed view of the mean power trace for $d = 1$ and the mean power trace for $d = 0$.

Steps in Differential Power Analysis

1. Choose an intermediate part of the algorithm to attack
   a. For example, function $f(d,k)$ where d is a data input and k is a small part of the secret key stored in the device under attack
   b. Typically d is either plaintext or ciphertext
2. Make a large number of power measurements
3. Calculate hypothetical intermediate values
4. Map hypothetical intermediate values to resulting predicted power values
5. Compare predicted power values with the actual trace values

Difference of Mean Power

- Consider MSB *v* of $S(p \oplus k)$
  - v=1 vs. v=0
- Calc. difference of 1000 traces: ½ with v=1, ½ with v=0
- Note key byte *k* has 256 guesses
- Peaks indicate correct guess!

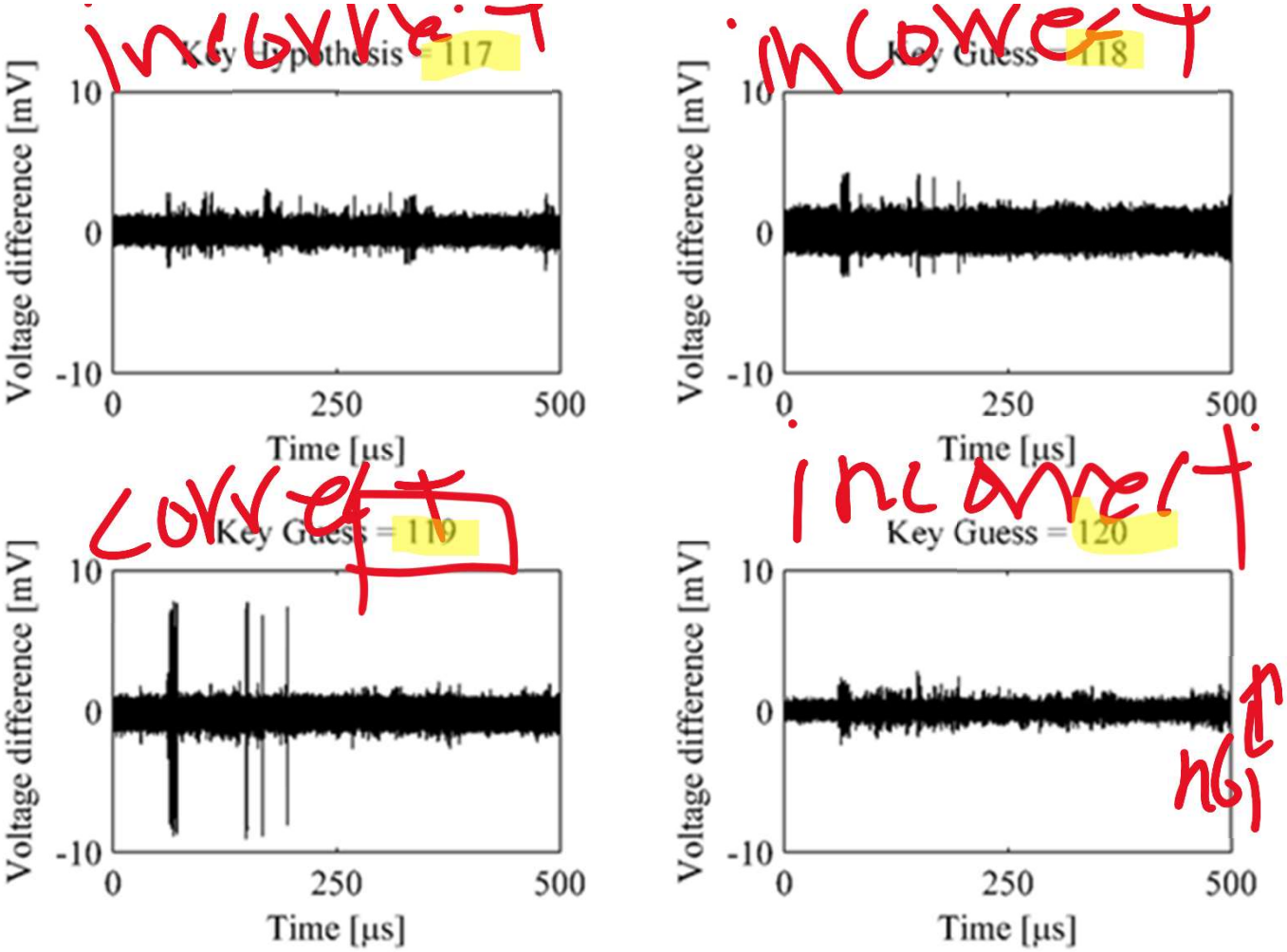


Figure 1.5. Difference plots for the key guesses 117, 118, 119, and 120.