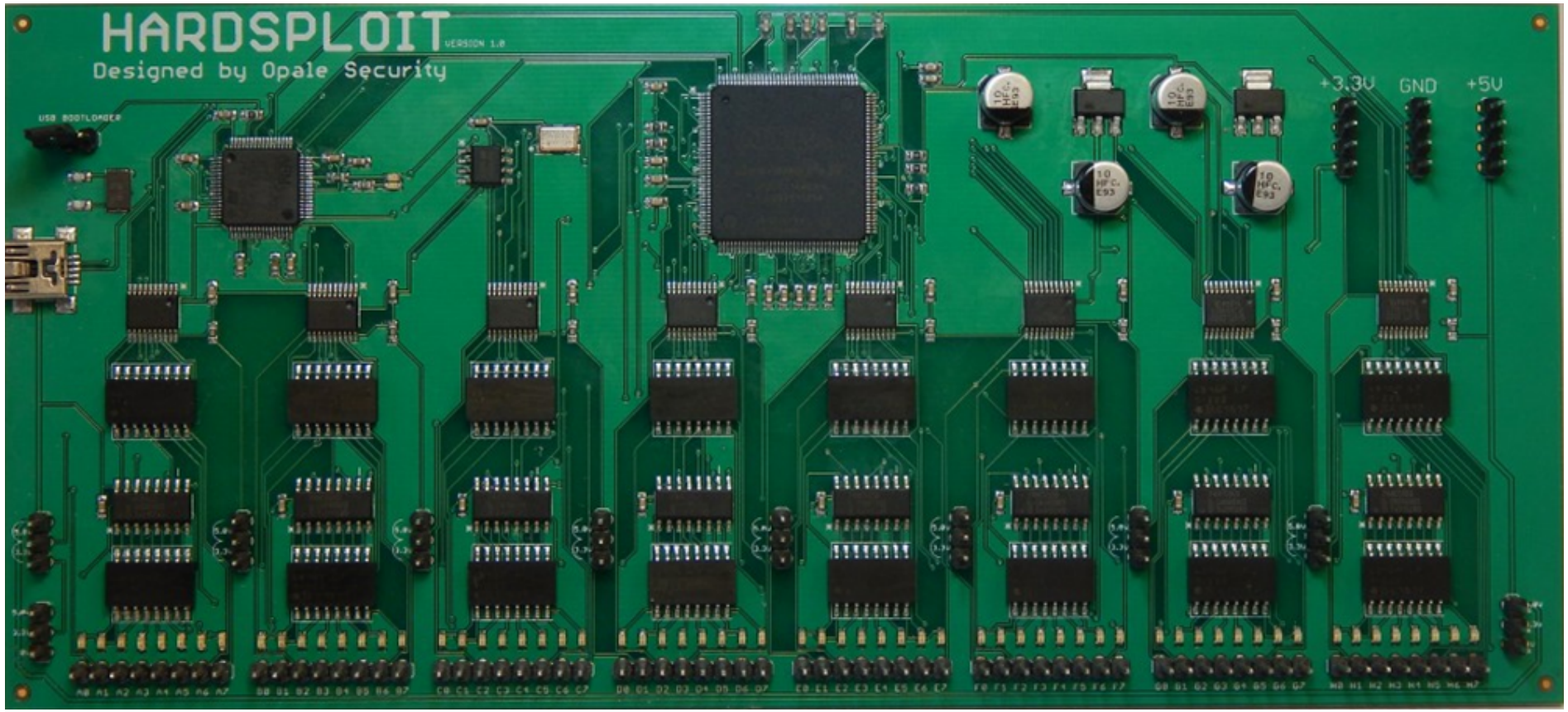
# HARDSPLOIT

## Framework for Hardware Security Audit

*a bridge between hardware & a software pentester*



# Who we are ?

- Julien Moinard
  - Electronic engineer @opale-security (French company)
  - Security consultant, Hardware & Software pentester
  - Team project leader of Hardsploit
  - DIY enthusiast

- Yann ALLAIN
  - CEO
  - Blackhat, HackInThebox, HIP, speaker & trainer
  - Cybersecurity veteran (+ 20 years) / (old) electronic engineer
  - Former CSO of ACCOR (software domain)

# Opale Security in 1 slide

# Internet of Things & Privacy concern ?

- **Any IoT object could reveal information about individuals**

- **Wearable Technology:** clothes, watches, contact lenses with sensors, microphones with cameras embedded and so on
- **Quantified Self:** pedometers, sleep monitors, and so on
- **Home Automation:** connected households using smart fridges, smart lighting and smart security systems, and so on
- …


# Internet of Things & Privacy concern ?

- **Last news : (you can update this slide every week ☹)**

BBC Sign in | News | Sport | Weather | Shop | Earth

NEWS

Home | Video | World | UK | Business | Tech | Science | Magazine | Enterta

Technology

**VTech hack: Parents complain of Christmas disappointment**

By Kevin Rawlinson
BBC News

5 January 2016 | Technology

VTech was hacked in November, exposing millions of accounts.

In response, the firm took some essential services offline, meaning products could not be registered on Christmas Day.


## Turning a Webcam Into a Backdoor

Posted by Vectra Threat Labs on Jan 12, 2016 5:00:00 AM

Firmware can be read without any problem (SPI memory)

# Iot Eco-system (20000 feet view)

- **Privacy Risk level : Where?**

HF communication (ISM Band) + Wifi + 3G-5G , Bluetooth, Sigfox, Lora etc..


IoT devices

Classical wired connections


Central servers, User Interface, API, Backoffice etc.

# Security speaking, hardware is the new software ?

Direct access

« Bridge » access

SOFTWARE

To secure it:

- Security products (Firewall, Antivirus, IDS,…)
- Security services (Pentest, Audit, …)
- Tools (Uncountable number of them)

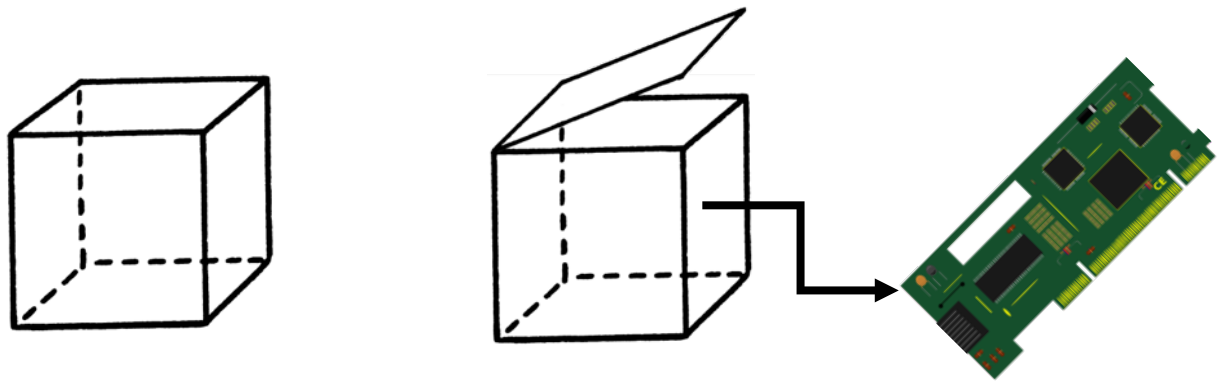
HARDWARE

To secure it:

- Few or unimplemented solutions (Encryption with key in a secure area, anti-replay mechanisms, readout protection, …)

# Hardsploit & hardware hacking basic procedure

- 1/ Open it
- **2/ Fingerprint all the component if you can else automatic brute forcing**
- 3/ Use those that may contain data (Online / Offline analysis ?)
- **4/ Perform read | write operation on them**
- 5/ Reverse engineering, find vulnerabilities and exploit them



# Global Purpose

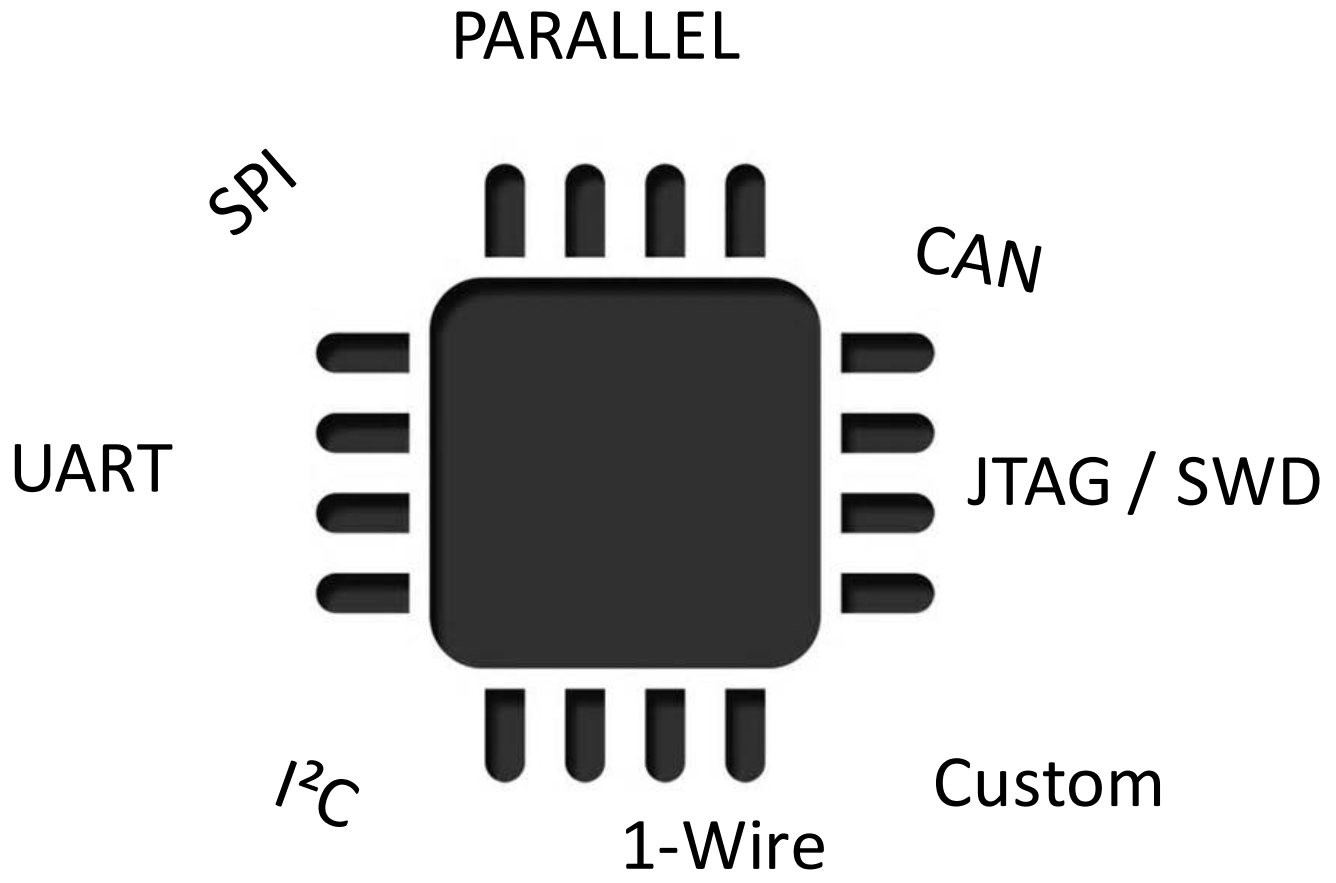
# Why ?

- Because chips contain interesting / private data
  - Passwords
  - File systems
  - Firmware
  - …

```
0000000 0000 0001 0001 1010 0010 0001 0004 0128
0000010 0000 0016 0000 0028 0000 0010 0000 0020
0000020 0000 0001 0004 0000 0000 0000 0000 0000
0000030 0000 0000 0000 0010 0000 0000 0000 0204
0000040 0004 8384 0084 c7c8 00c8 4748 0048 e8e9
0000050 00e9 6a69 0069 a8a9 00a9 2828 0028 fdfc
0000060 00fc 1819 0019 9898 0098 d9d8 00d8 5857
0000070 0057 7b7a 007a bab9 00b9 3a3c 003c 8888
0000080 8888 8888 8888 8888 288e be88 8888 8888
0000090 3b83 5788 8888 8888 7667 778e 8828 8888
00000a0 d61f 7abd 8818 8888 467c 585f 8814 8188
00000b0 8b06 e8f7 88aa 8388 8b3b 88f3 88bd e988
00000c0 8a18 880c e841 c988 b328 6871 688e 958b
00000d0 a948 5862 5884 7e81 3788 1ab4 5a84 3eec
00000e0 3d86 dcb8 5cbb 8888 8888 8888 8888 8888
00000f0 8888 8888 8888 8888 8888 8888 8888 0000
0000100 0000 0000 0000 0000 0000 0000 0000 0000
*
0000130 0000 0000 0000 0000 0000 0000 0000
000013e
```

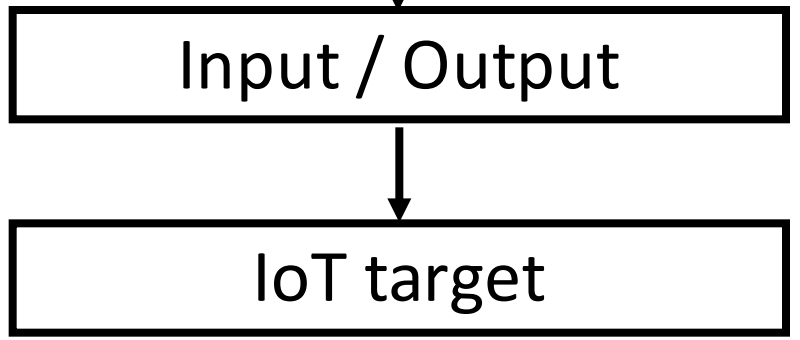
# How ?

- A hardware pentester need to know electronic buses and he need to be able to interact with them



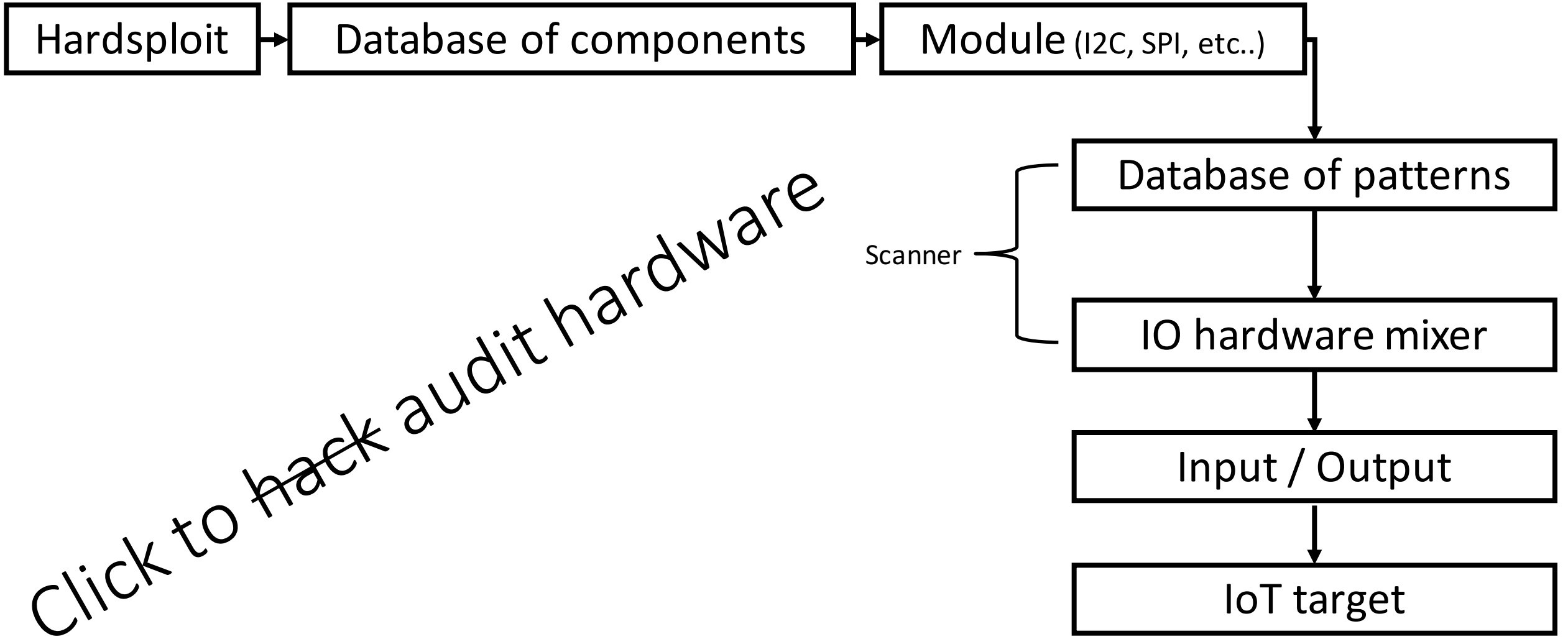
# Hardsploit framework


**Same hardware** but a software update is needed to add a new protocols



# Hardsploit bus indentification & scanner

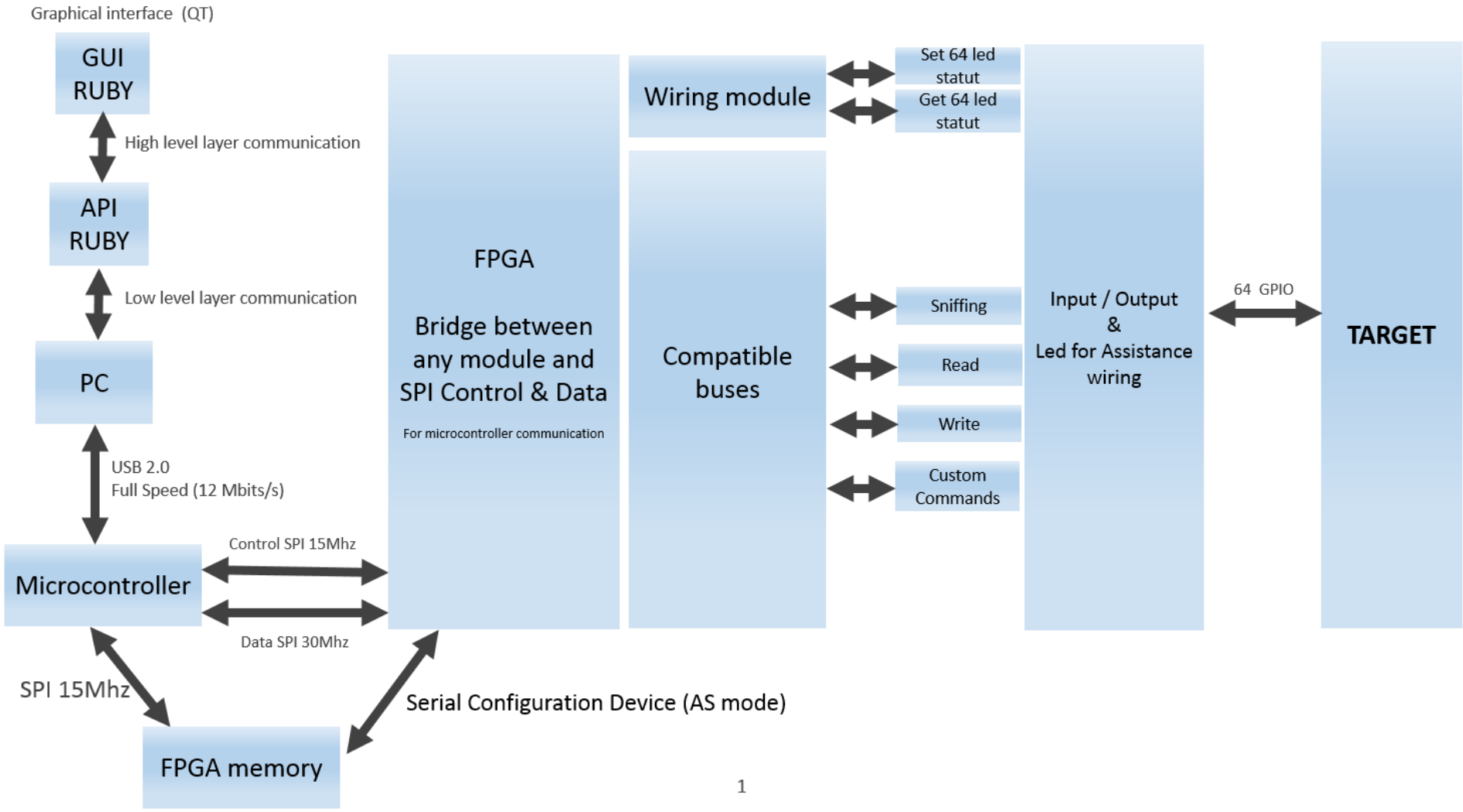
(in progress, not published yet)



# Tool of trade

| FUNCTIONALITIES | BUSPIRATE | JTAGULATOR | GOODFET | HARDSPLOIT |
|---|---|---|---|---|
| UART | O | Bus identification | X | O |
| SPI | O | X | O | O |
| PARALLEL | X | X | X | O |
| I2C | O | X | X | O |
| JTAG / SWD | O | Bus identification | O | O |
| MODULARITY | Microcontroller | Microcontroller | Microcontroller | uC / FPGA |
| EASE OF USE | Cmd line + datasheet | Command line | Command line | Official GUI / API / DB |
| I/O NUMBER | < 10 | 24 | < 14 | 64 (plus power) |
| WIRING | TEXT (but MOSI = SDA ☺) | TEXT / AUTOMATIC identification | TEXT | LED / TEXT/ AUTOMATIC identification |

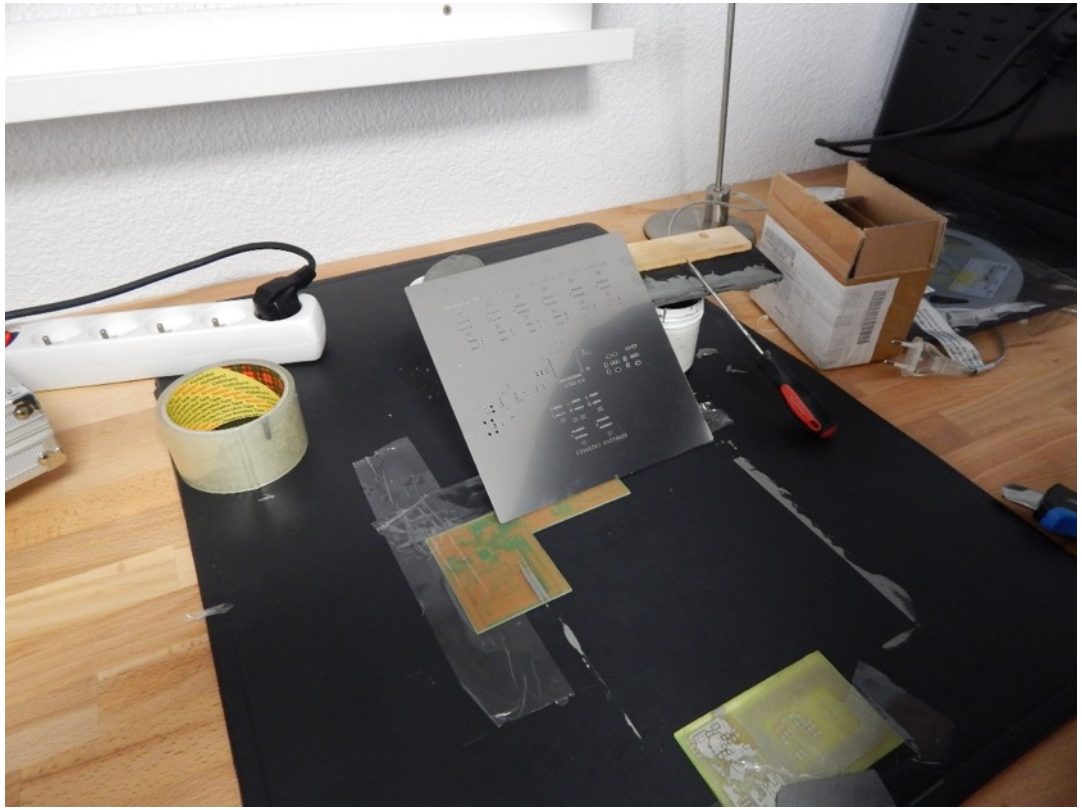
# Hardsploit: Communication

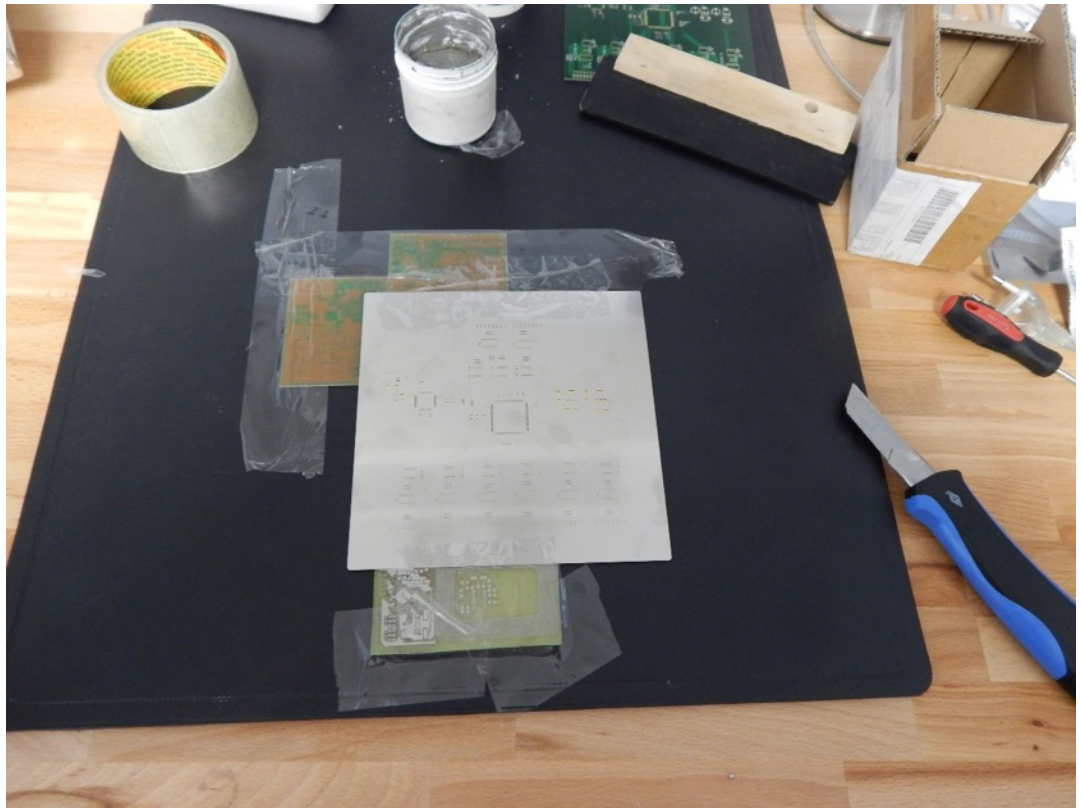



1

# Prototype making

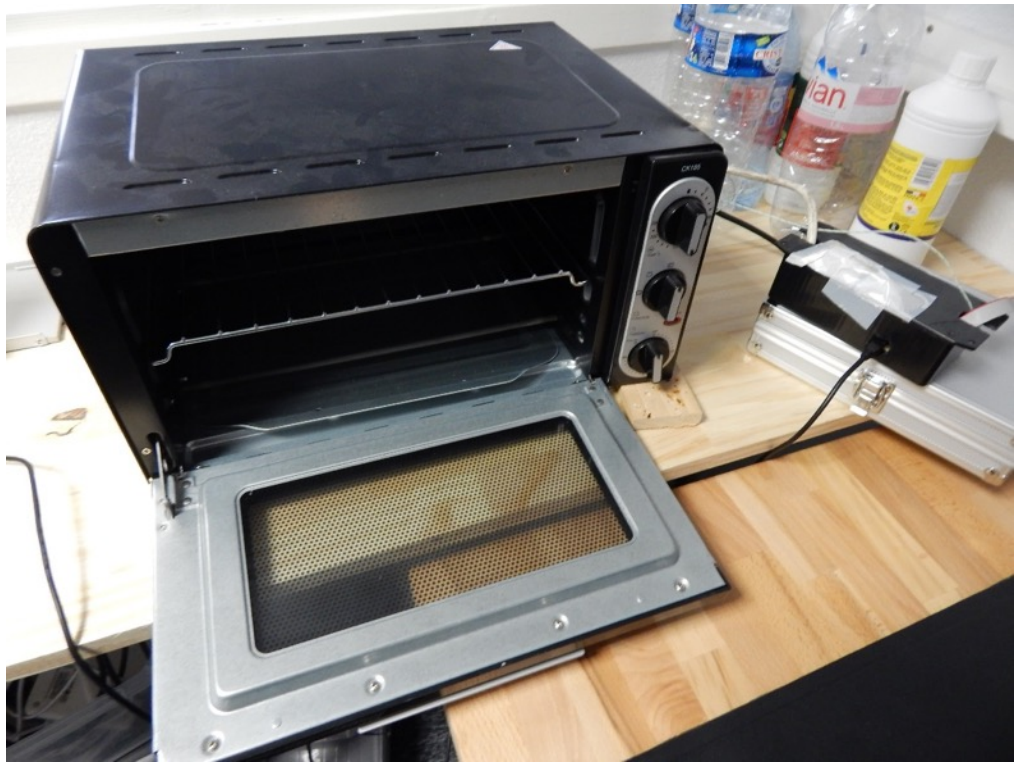
- Applying soldering paste (low budget style)

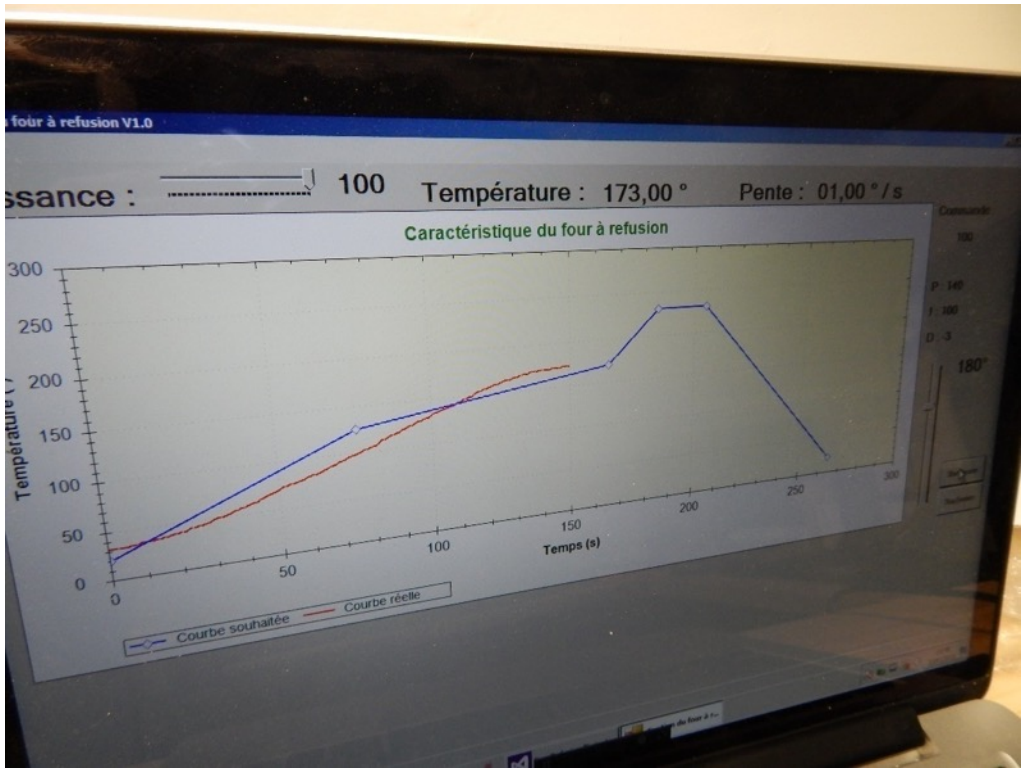




# Prototype making

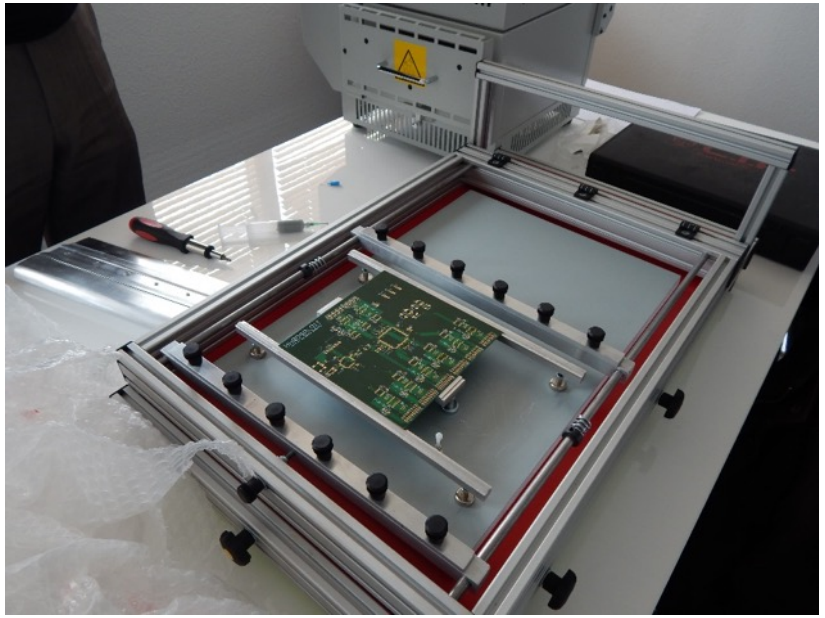
- Manual reflow oven (DIY style)

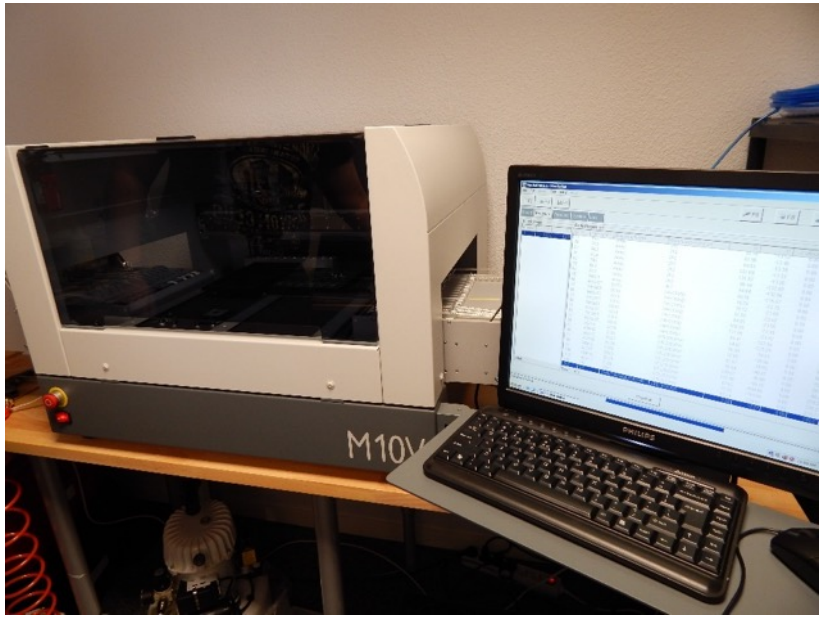




# Prototype making (with a budget)

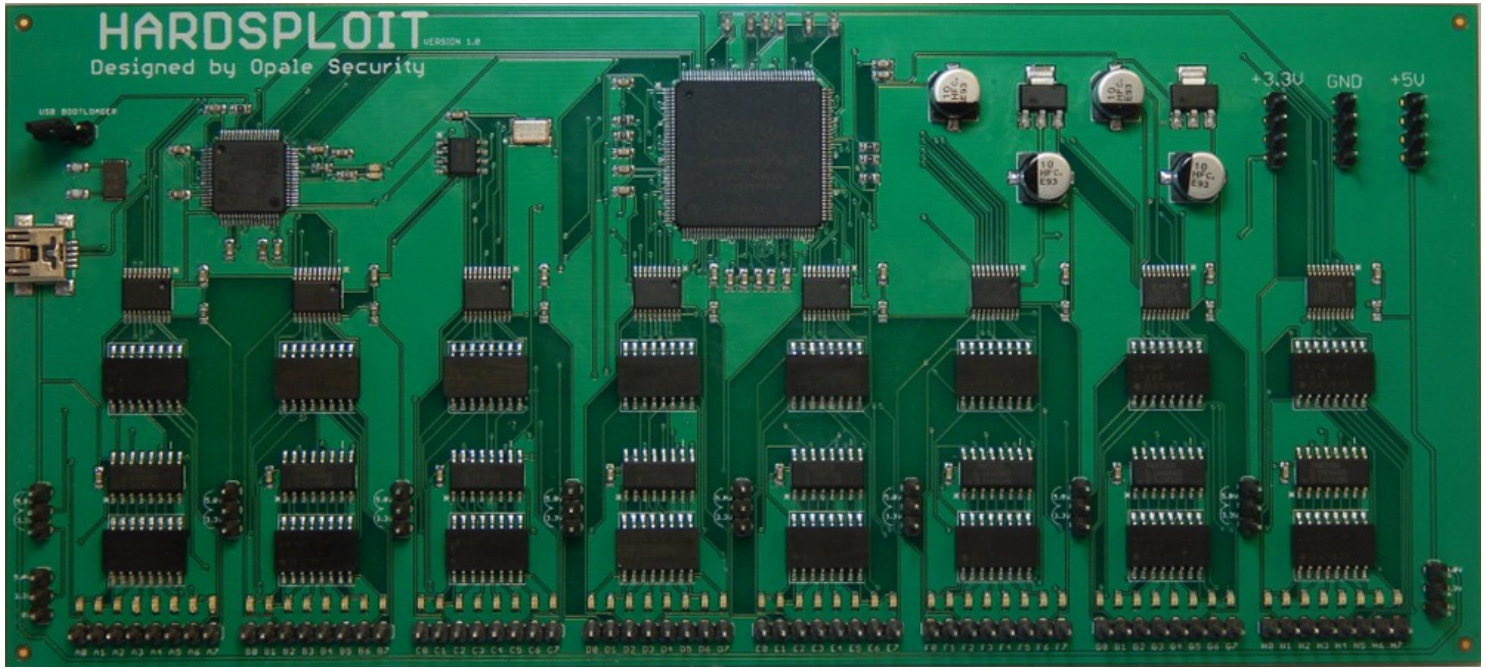
- The rebirth



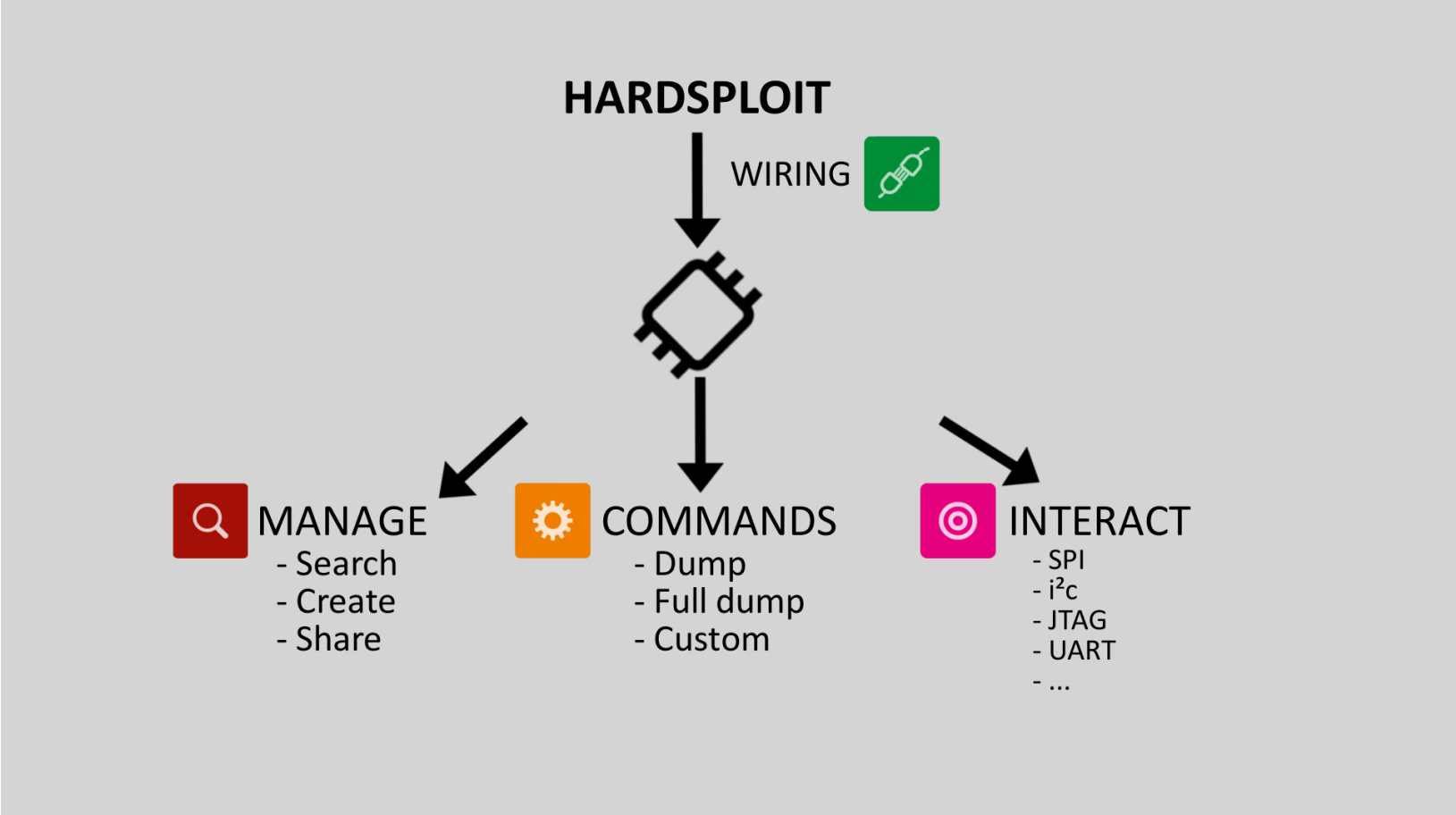


# The board – Final version

- 64 I/O channels
- ESD Protection
- Target voltage: 3.3 & 5V
- Use a Cyclone II FPGA
- USB 2.0
- 20cm x 9cm

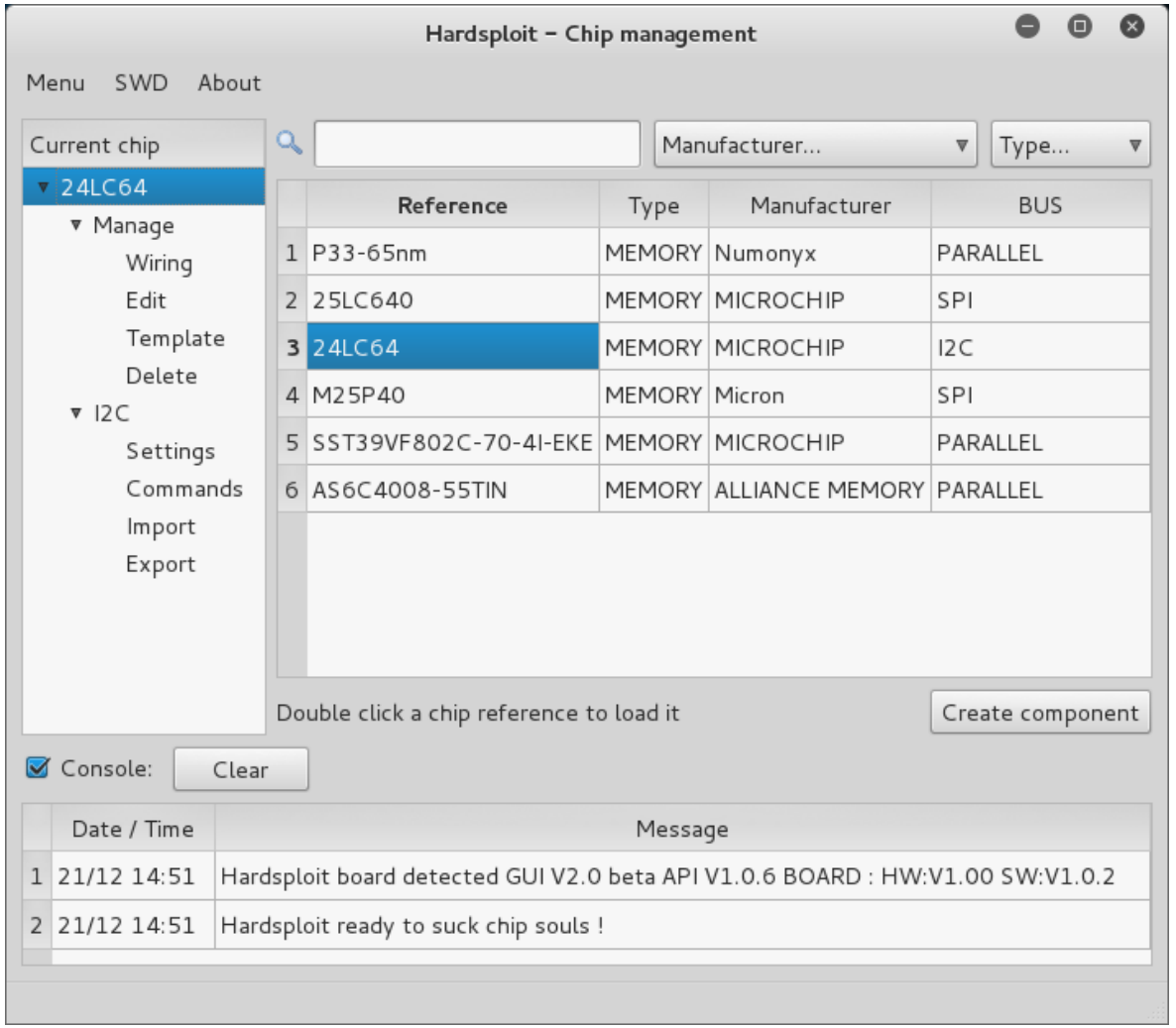


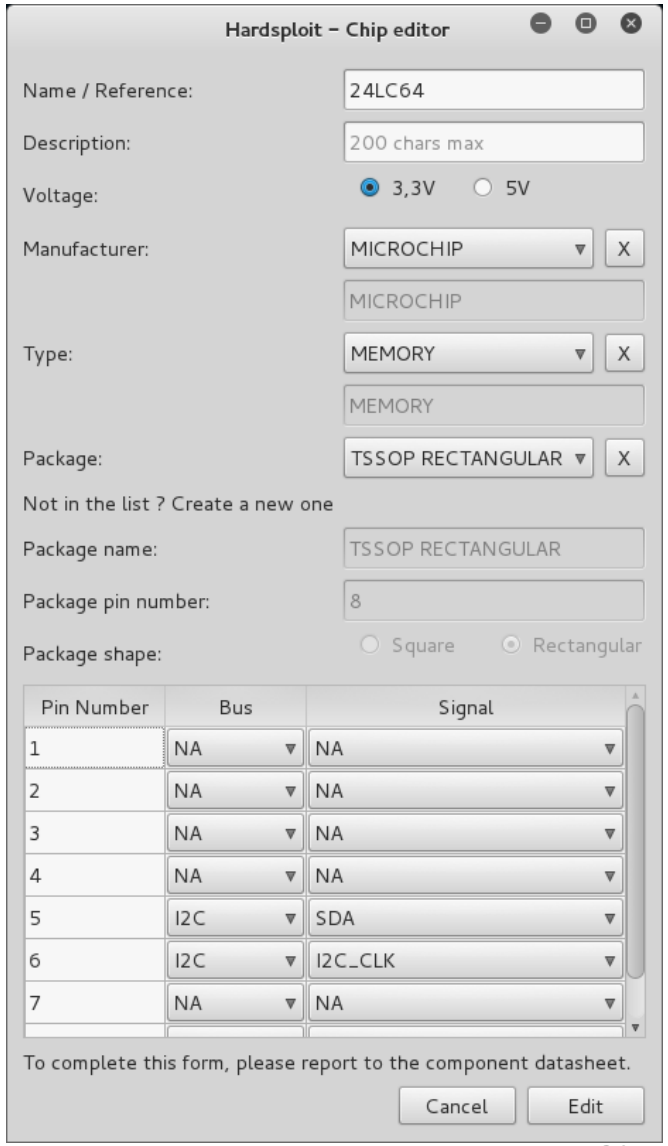
# Hardsploit organization



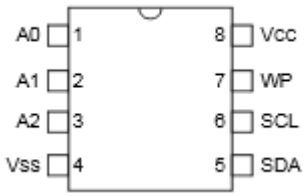
# Chip management

- Search
- Create
- Modify
- Interact

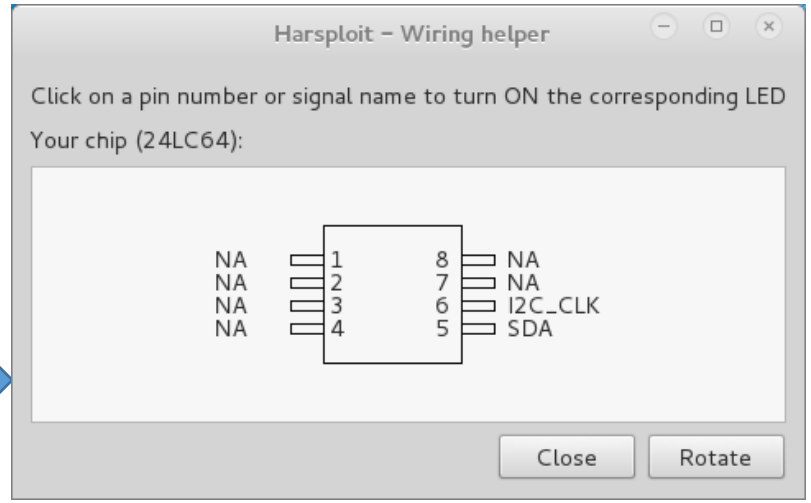


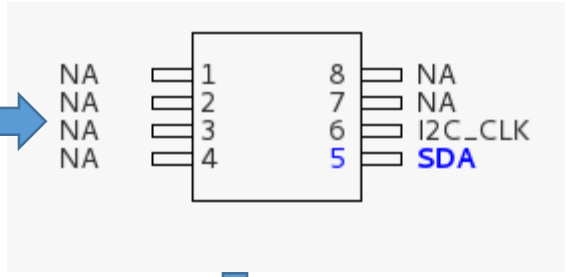



# Wiring helper

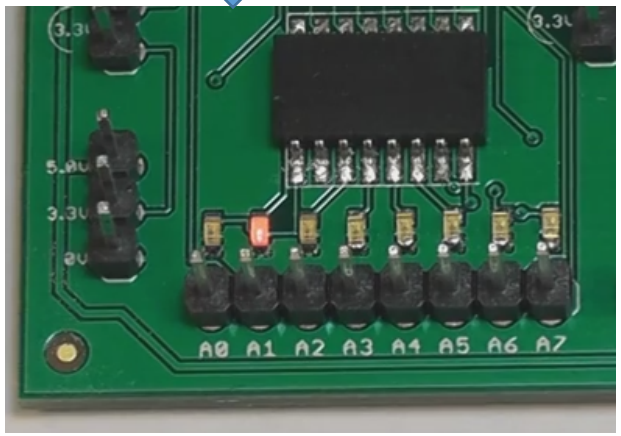



Datasheet representation



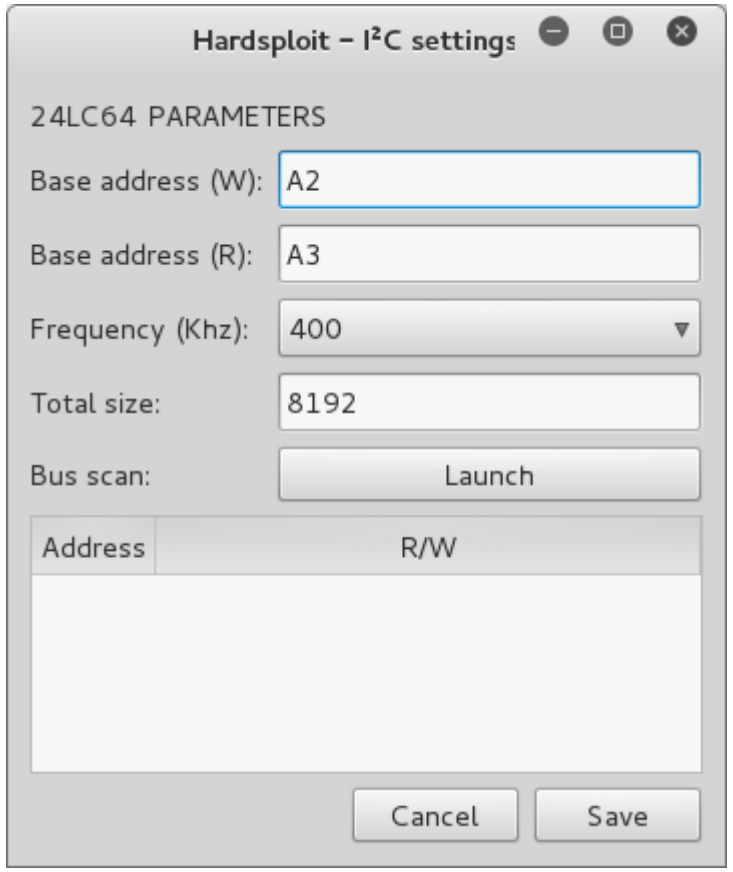



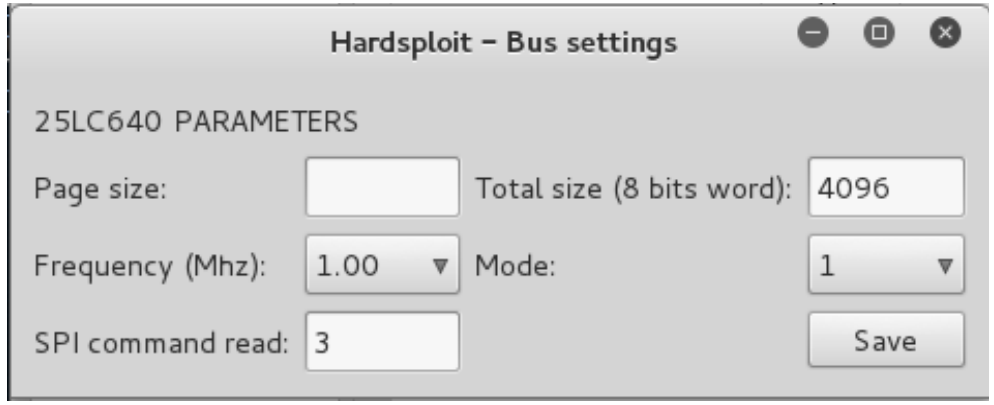

GUI <–> Board interaction

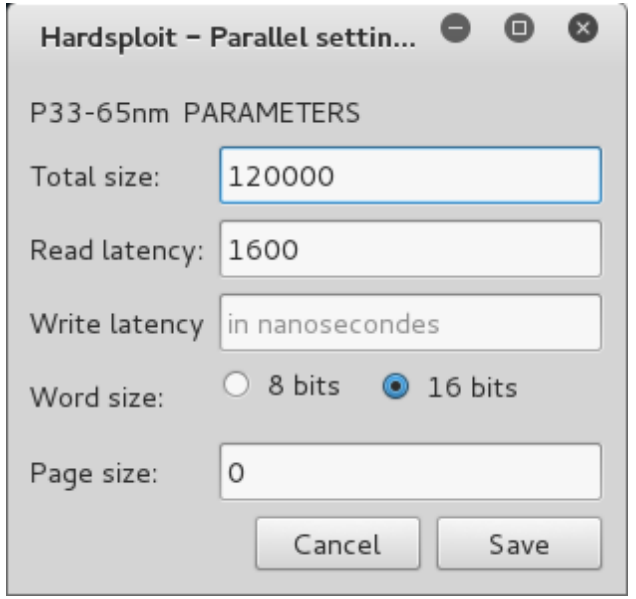



Hardsploit Wiring module representation

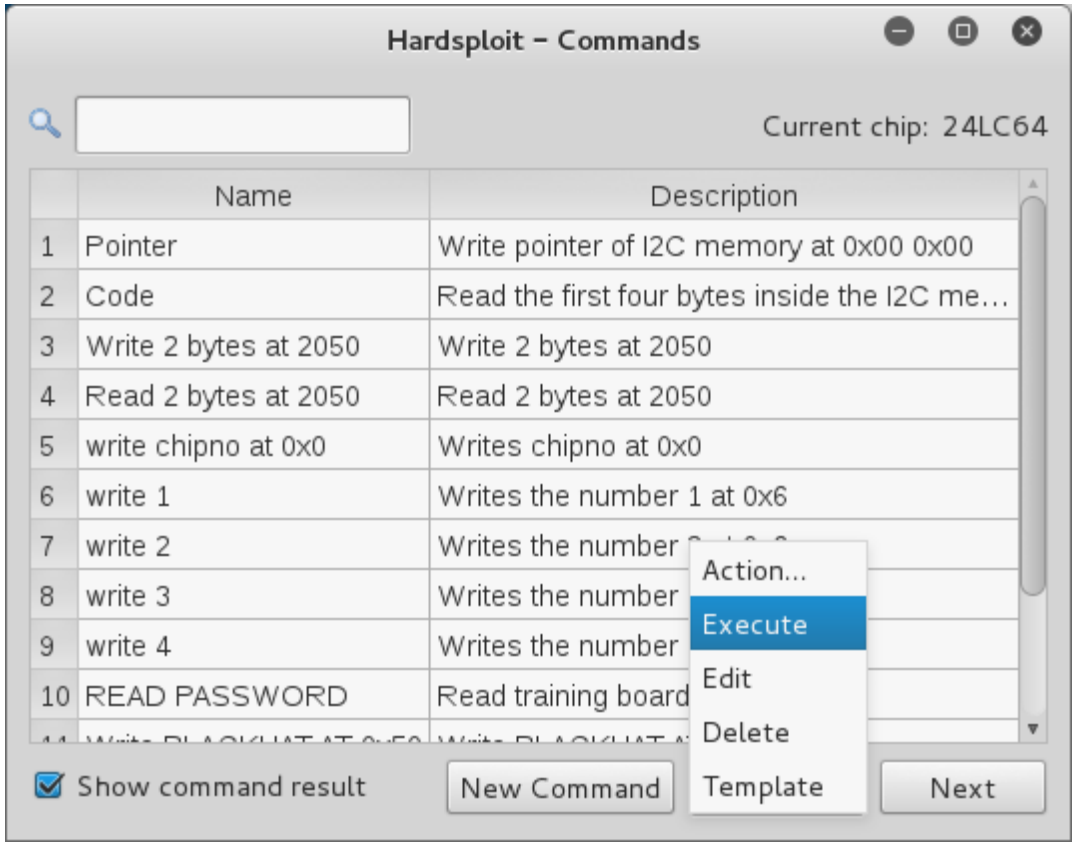
# Settings

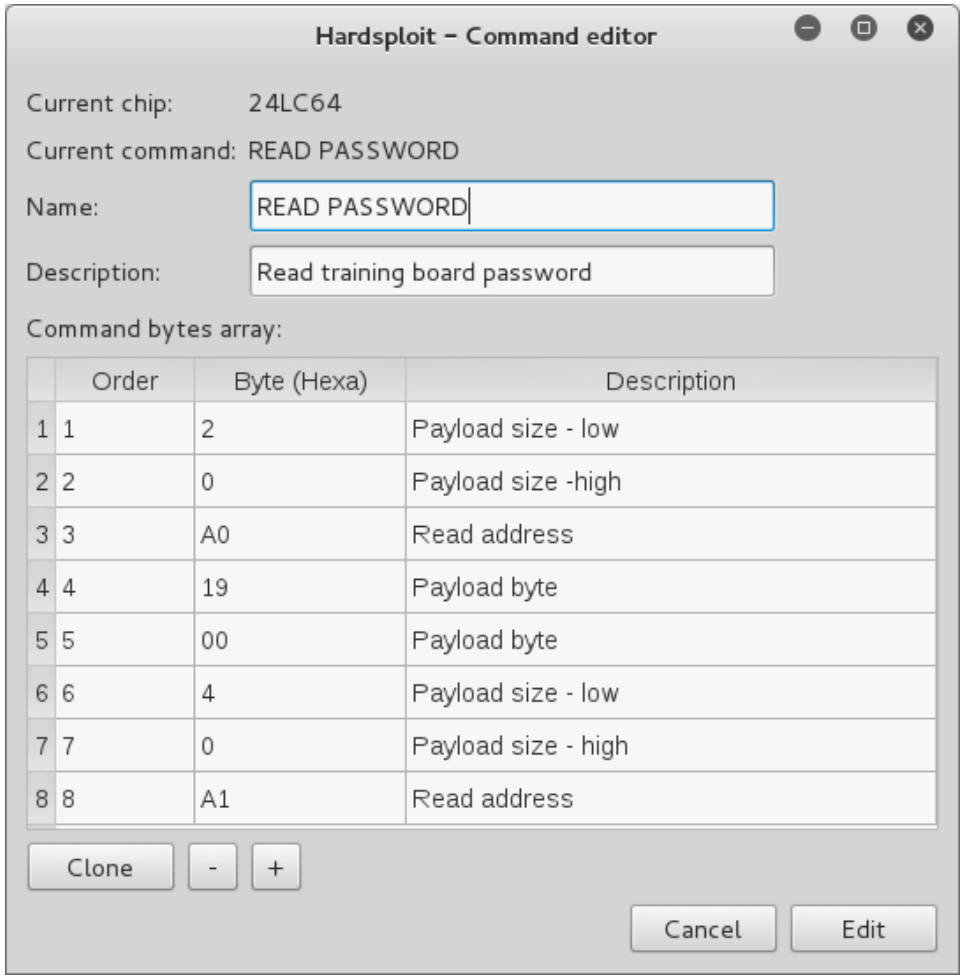

Hardsploit – I²C settings
24LC64 PARAMETERS
Base address (W): A2
Base address (R): A3
Frequency (Khz): 400
Total size: 8192
Bus scan: Launch
Address
R/W
Cancel
Save


Hardsploit – Bus settings
25LC640 PARAMETERS
Page size:
Total size (8 bits word): 4096
Frequency (Mhz): 1.00
Mode: 1
SPI command read: 3
Save


Hardsploit – Parallel settin...
P33-65nm PARAMETERS
Total size: 120000
Read latency: 1600
Write latency in nanosecondes
Word size: 8 bits 16 bits
Page size: 0
Cancel
Save

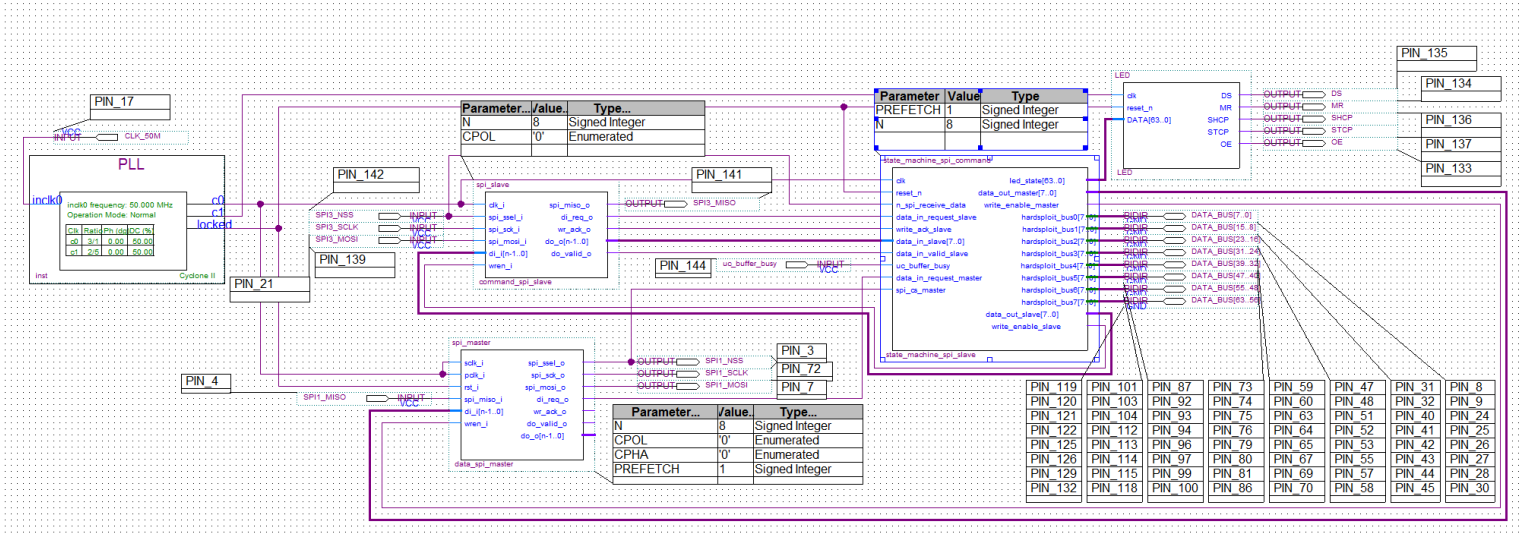
# Command editor



# What are available on github (Open) ?

- Microcontroller (c)
- API (ruby)
- GUI (ruby)
- Create your own Hardsploit module : VHDL & API (ruby)



# Already available (github)

Parallel non multiplexed memory dump

- 32 bits for address
- 8/16 bits for data

Helping wiring

I2C 100Khz 400Khz and 1 Mhz

- Addresses scan
- Read, write, automatic full and partial dump

SPI mode 0,1,2,3 up to 25 Mhz

- Read, write, automatic full and partial dump

SWD interface (like JTAG but for ARM core)

- Dump and write firmware of most ARM CPU

GPIO interact / bitbanging (API only for the moment)

- Low speed < 500Hz  read & write operations on 64 bits

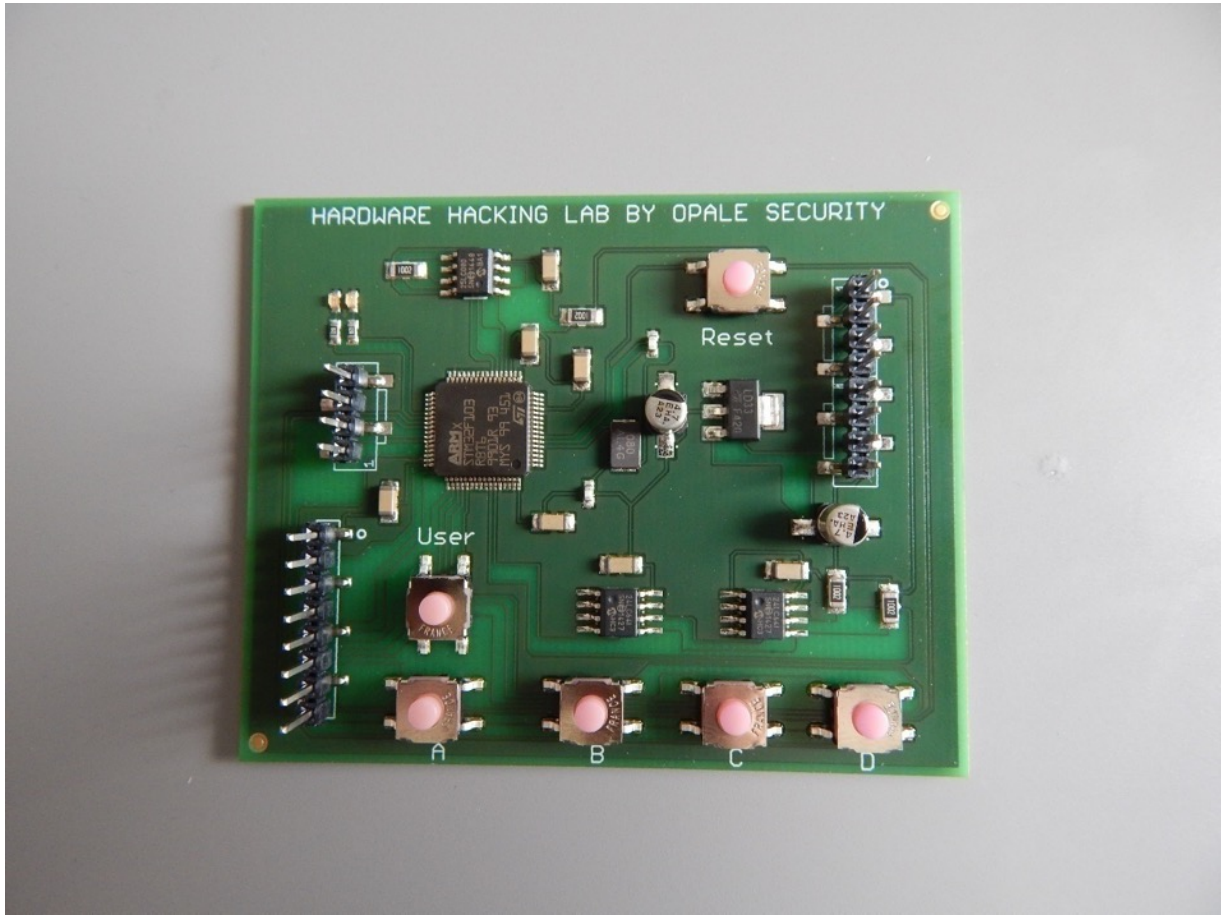
# More to come (see online roadmap)…

- Automatic bus indentification & Scanner (@30%)
- Component & commands sharing platform (@90%)
- TTL UART Module with automatic detection speed (@80%)
- Parallel communication with multiplexed memory
- I2C sniffing (shot of 4000 bytes up to 1 Mhz)
- SPI sniffing (shot of 8000 / 4000 byte half / full up to 25Mhz)
- RF Wireless transmission training plateform (Nordic NRF24, 433Mhz, 868Mhz transcievers)
- Metasploit integration (module) ??
- JTAG
- 1 Wire
- CanBUS (with hardware level adapter)
- …

# Concrete case

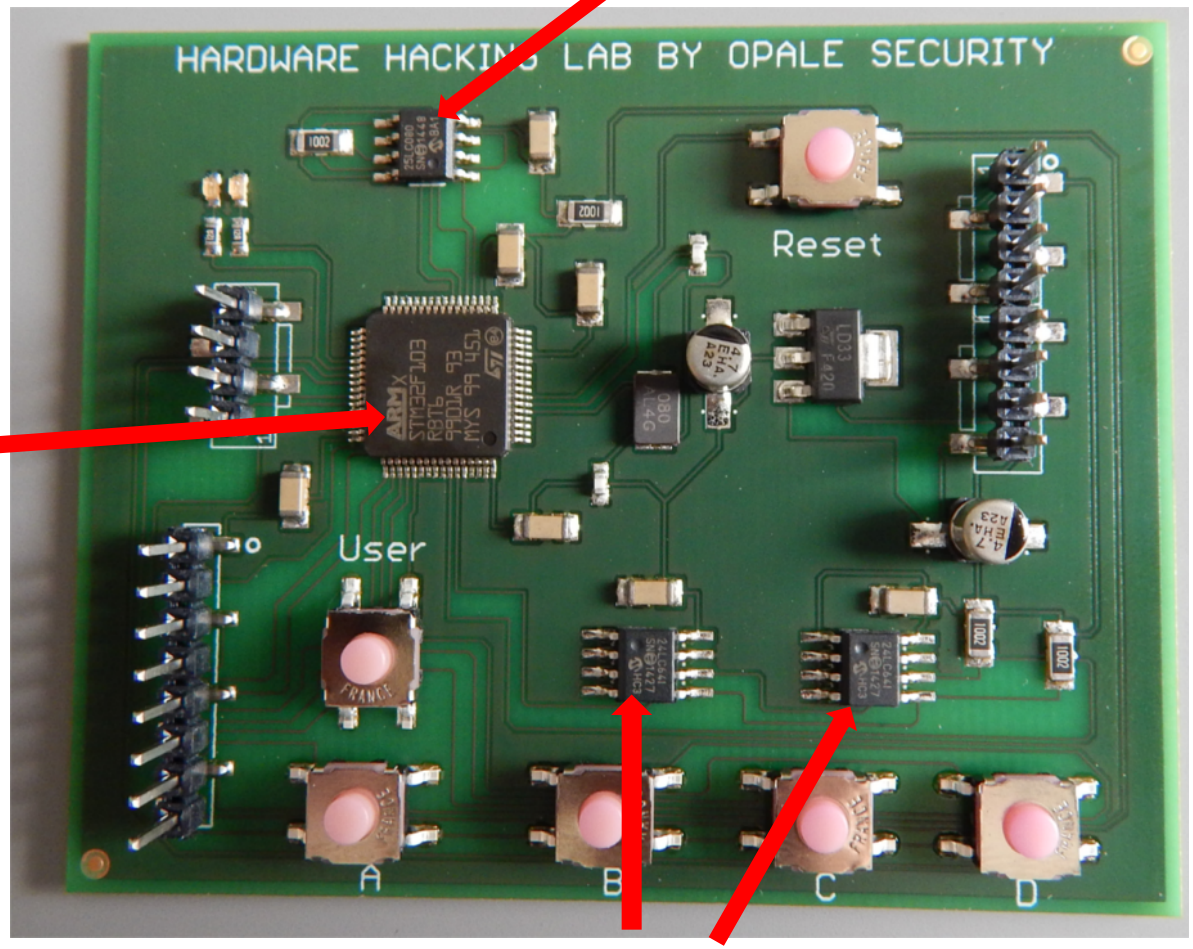
- An electronic lock system
- 4 characters pin code A – B – C – D
  - Good combinaison – Door opens, green L.E.D turn on
  - Wrong combinaison – Door closes, red L.E.D turn on

# Concrete case: Open it



# Concrete case: Fingerprint

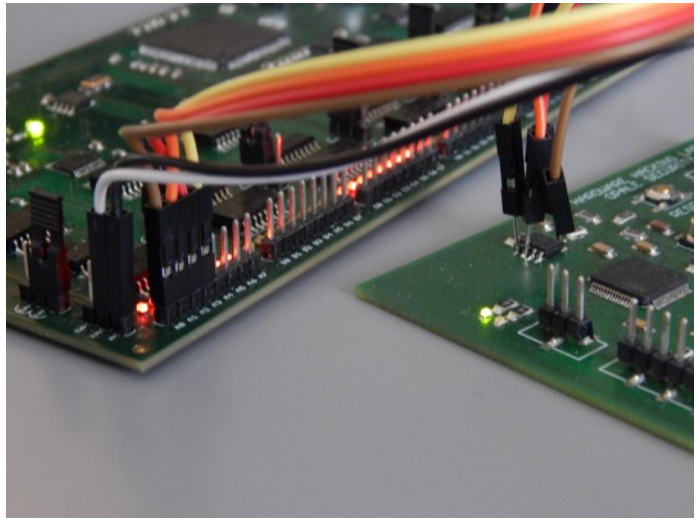
SPI MEMORY 25LC08

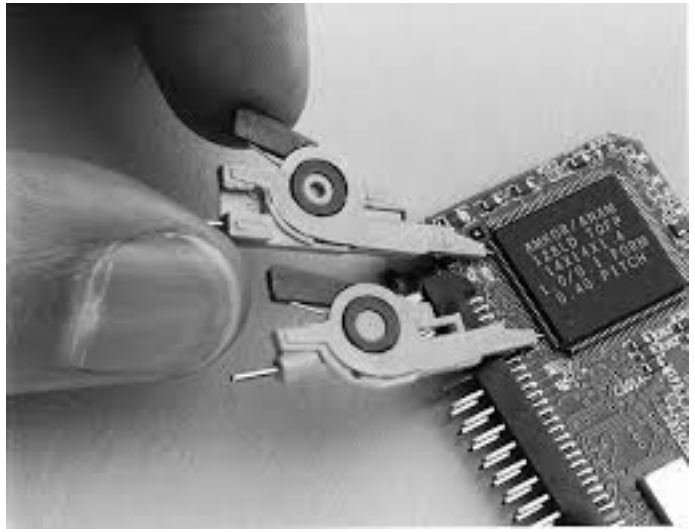


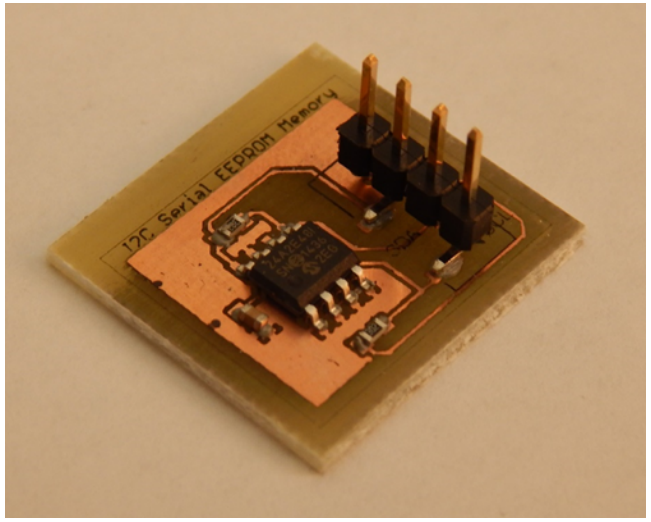

STM32F103RBT6

I2C MEMORIES 24LC64

# Concrete case: Online / Offline analysis ?







# Concrete case: hardsploit scenario

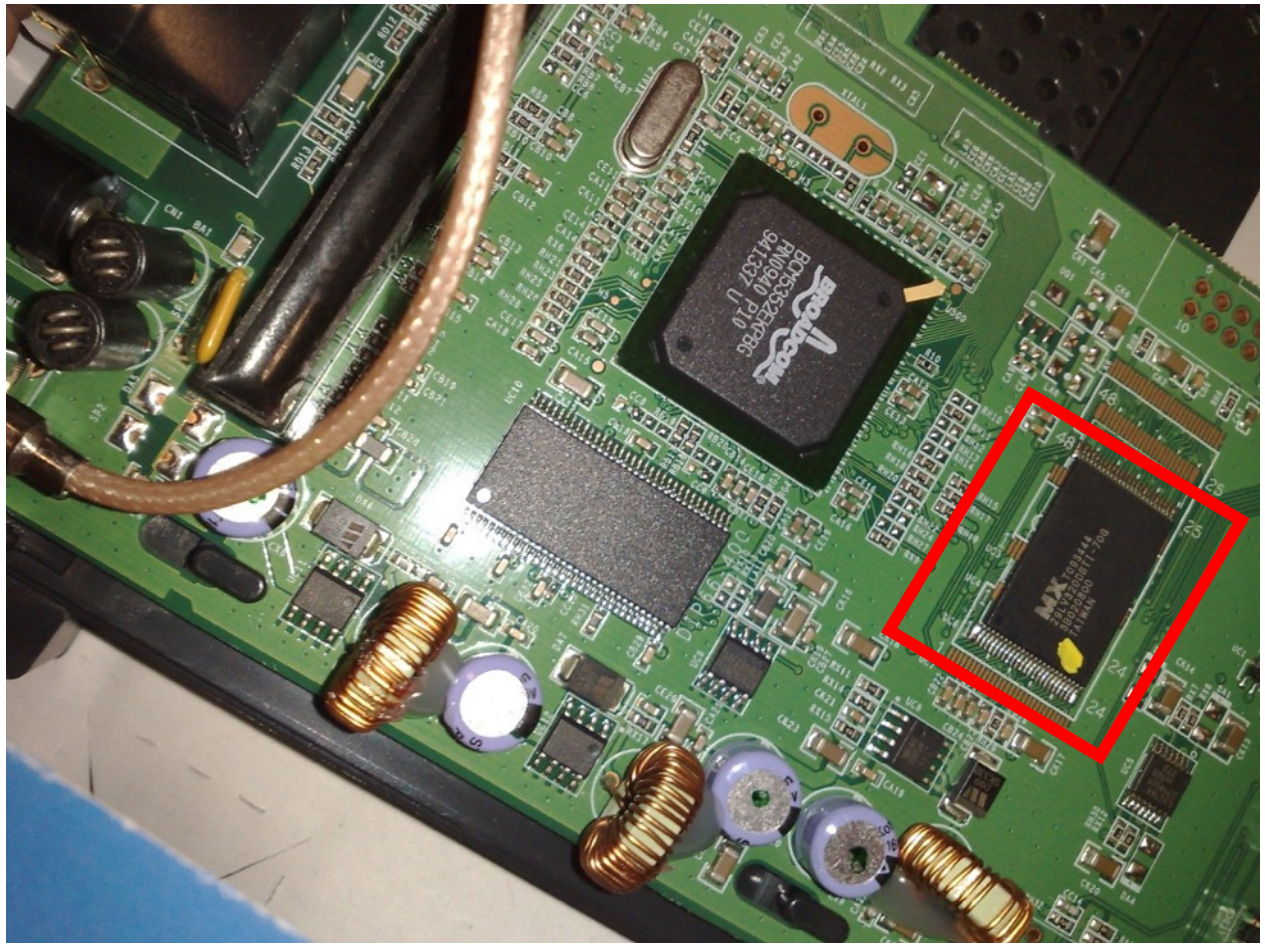
1. Open Hardsploit to create the component (if not exist)
2. Connect the component to Hardsploit (wiring helping)
3. Enter and save the component settings (if not exist)
4. Dump the content of the memories (1 click)
5. Change the door password by using commands (few clicks)
6. Try the new password on the lock system (enjoy)

# Concrete case:
# Read | Write operation, I2C, SPI, SWD …

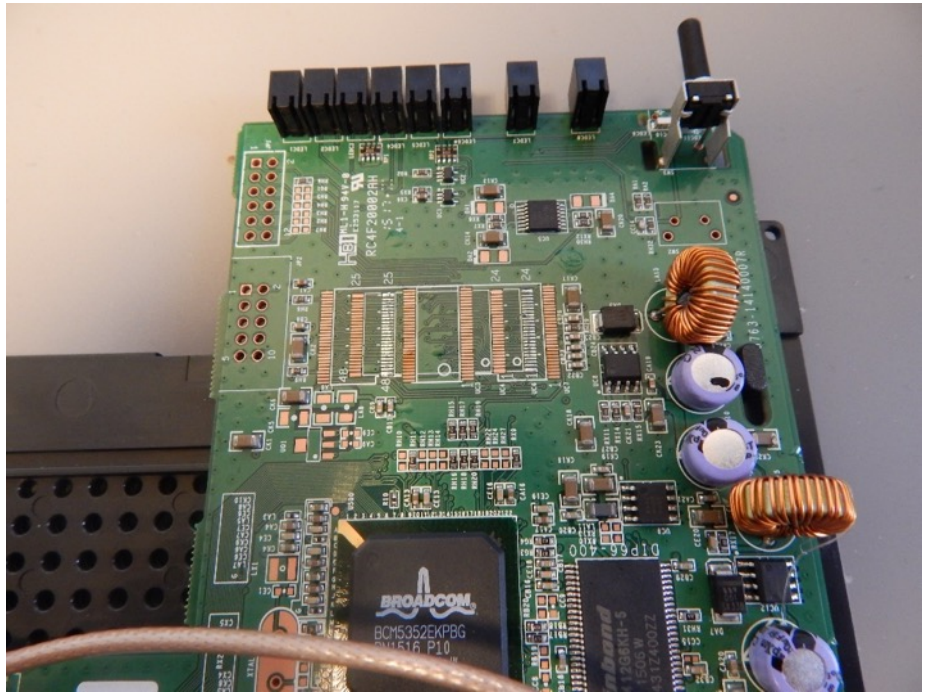
- Time for a live demo ?

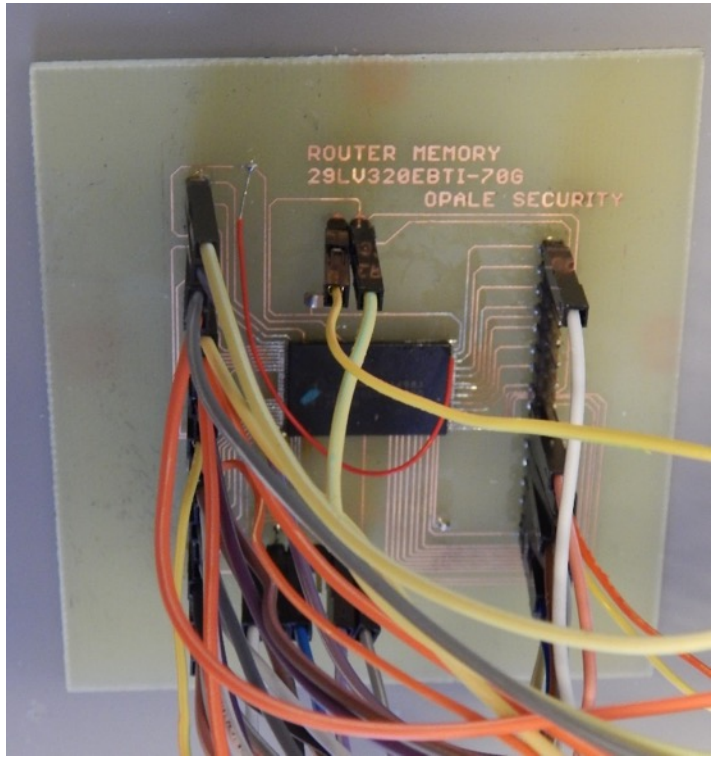
# Parallel bus memory

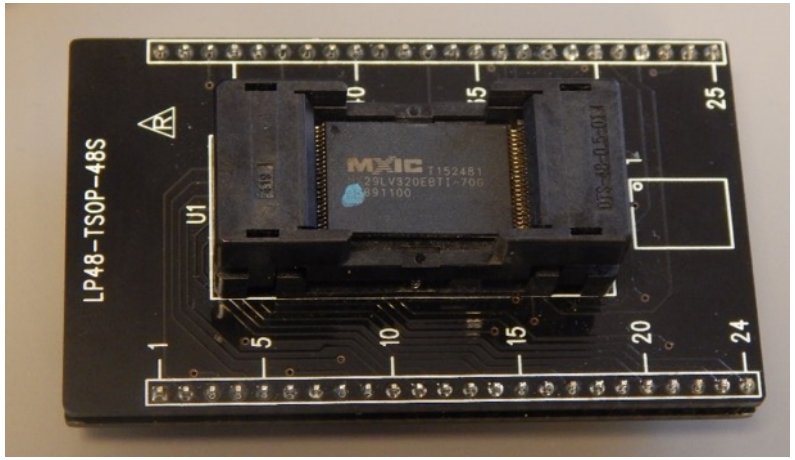
# Concrete case: Fingerprint



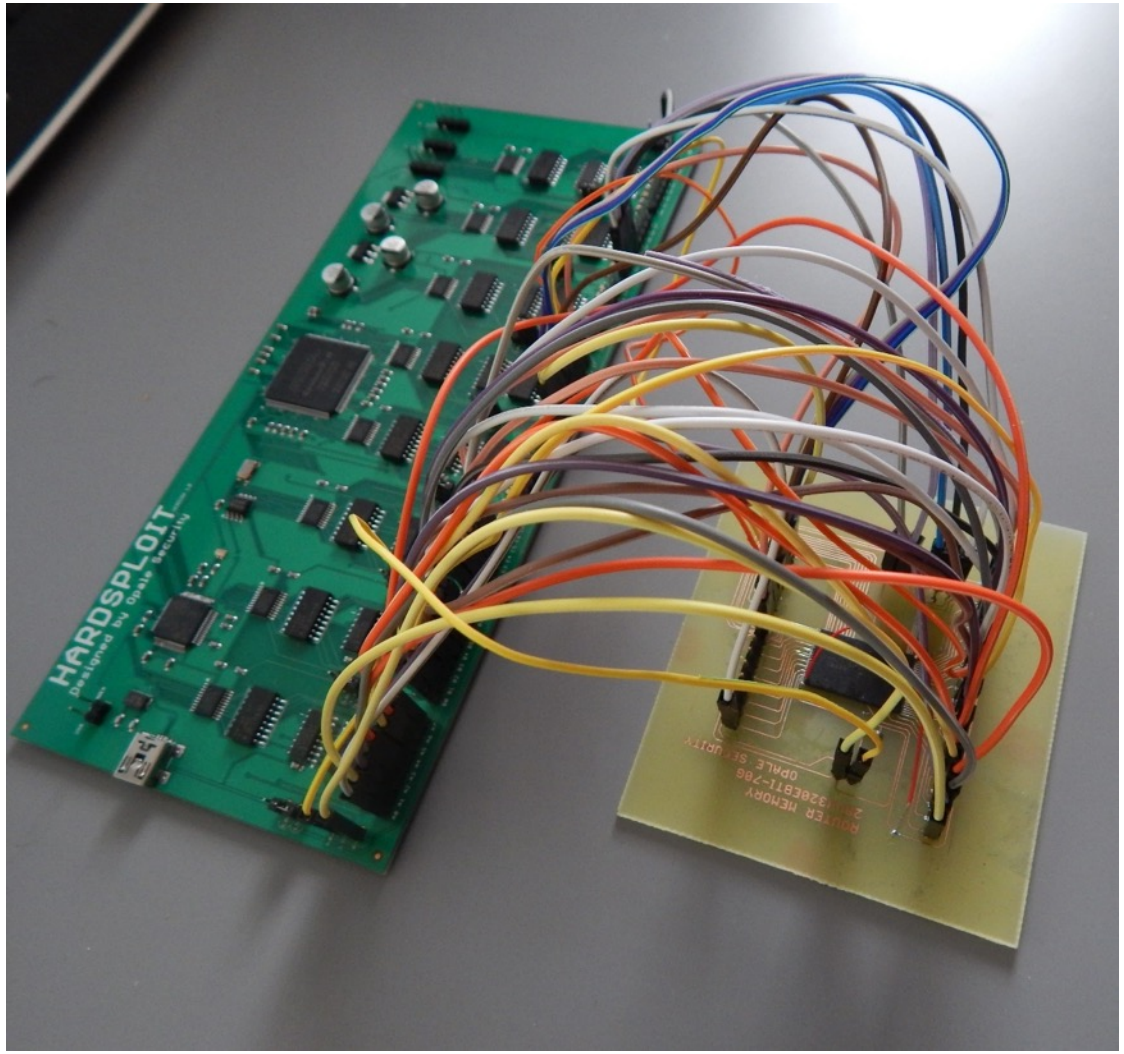
# Concrete case: Offline analysis



# Concrete case: Ready to dump the content




/root/Bureau/FirmwareRouter.bin – Bless

File Edit View Search Tools Help

FirmwareRouter.bin ×

```
00000000 17 08 A4 2C 12 F1 85 19 41 77 85 19 DB 7B 85 19 48 44 D5 ...,....Aw...{..HD.
00000013 E6 88 78 85 19 D8 B2 85 19 76 DD 85 19 E8 FF E9 87 4D 3E ..x......v.......M>
00000026 85 19 0C 14 85 19 25 28 85 19 CB E9 A4 34 5C 4C 85 19 E0 ......%(.....4\L...
00000039 36 85 19 8A DC 85 19 0E 00 C2 DF 35 BE 85 19 9A 88 85 19 6..........5.......
0000004c 3B 28 85 19 31 4C 1B E4 0A 55 85 19 2D 86 85 19 59 30 85 ;(..1L...U..-...Y0.
0000005f 19 04 00 F9 70 21 CD 85 19 75 30 85 19 AE 0A 85 19 E2 64 ....p!...u0.......d
00000072 85 19 5E DC 85 19 97 CC 85 19 D3 4D FF FF 69 6E CD 52 65 ..^........M..in.Re
00000085 2C FF FF 26 4B FF FF 3E 32 FF FF E3 D8 03 BF 91 E0 FF FF ,..&K..>2..........
00000098 66 0E FF FF A3 29 FF FF 10 00 E1 37 02 1B FF FF 72 7A FF f....).....7....rz.
000000ab FF E3 D7 FF FF 25 1C 00 00 00 2B FF FF 0A 41 FF FF 87 69 .....%....+...A...i
000000be FF FF 21 A0 05 35 0E 2A FF FF 76 48 FF FF D6 95 FF FF C8 ..!..5.*..vH.......
000000d1 E8 D6 04 93 07 FF FF 9C 96 FF FF 2F 7E FF FF 76 65 ED 3C ...........~..ve.<
000000e4 B9 7C FF FF 24 72 FF FF 9D 86 FF FF 94 D7 FF FF E4 B6 FF .|..$r..............
000000f7 FF B8 5A FF FF F8 5E 46 4C 61 64 34 95 20 E1 FF FF ED 17 ..Z...^FLad4. .....
0000010a FF FF C4 A4 FF FF 6B D6 11 47 B9 61 FF FF 4A 8A FF FF BA ......k..G.a..J....
0000011d FF FF FF 00 00 53 84 28 2E FF FF 7E FF FF FF E7 C6 FF FF .....S.(...~.......
00000130 10 60 12 DC F0 83 FF FF 1B F9 FF FF BD 54 FF FF 21 38 83 .`...........T..!8.
00000143 D8 87 FC FF FF 19 8F FF FF 94 AC FF FF 68 74 ED D6 02 0E .............ht....
00000156 FF FF AE 08 FF FF 31 1A FF FF 58 20 E2 E1 77 37 FF FF 0A ......1...X ..w7...
00000169 60 FF FF 2C 83 FF FF 37 5E FF FF D3 6F FF FF 4C 8D FF FF `..,...7^...o..L...
0000017c 75 96 FF FF 03 00 3D FA 9E D3 FF FF FF 45 FF FF F9 6C FF u.....=......E...l.
0000018f FF 5C 3D 3B 6C 7C BD FF FF 2D 18 FF FF 1A 01 FF FF 00 00 .\=;l|...-..........
000001a2 45 57 A1 8A FF FF 85 64 FF FF 75 02 FF FF 2F 1E 00 00 86 EW.....d..u.../.....
000001b5 3A FF FF 9D C9 FF FF BE 19 FF FF 08 00 A0 AB 21 6F FF FF :.............!o..
000001c8 15 95 FF FF C5 66 FF FF C2 A5 F8 59 ED A3 FF FF 84 6F FF .....f.....Y.....o.
000001db FF 74 6D FF FF 00 08 34 7C 58 3B FF FF 63 BC FF FF B2 08 .tm....4|X;..c.....
000001ee FF FF EA 7C FF FF 0D D5 FF FF 06 6B FF FF 76 19 FF FF 70 ...|.......k..v...p
00000201 9E 9D 0D DB 50 FF FF 30 F8 FF FF 9B 97 FF FF 24 23 B4 E6 ....P..0.......$#..
```

| | | | | | |
|---|---|---|---|---|---|
| Signed 8 bit: | 23 | Signed 32 bit: | 386442284 | Hexadecimal: | 17 08 A4 2C |
| Unsigned 8 bit: | 23 | Unsigned 32 bit: | 386442284 | Decimal: | 023 008 164 044 |
| Signed 16 bit: | 5896 | Float 32 bit: | 4,415118E-25 | Octal: | 027 010 244 054 |
| Unsigned 16 bit: | 5896 | Float 64 bit: | 1,03014042409718E-197 | Binary: | 00010111 00001000 10 |

Show little endian decoding  Show unsigned as hexadecimal  ASCII Text: ?.

Offset: 0x0 / 0x3d0900  Selection: None  INS

# Conclusion

- IoT Device are (also) prone to vulnerabilities help you to find them
- Security policy need to be adpated, nowadays, it is not so difficult to extract data on IoT
- Designers need to design with security in mind
- Skills related to pentest a hardware device is mandatory for Security Experts (but training exist)
- Industry need to take care about device security

# Thank you !


Hardsploit board is available at **shop-hardsploit.com (250 € / 277 USD / 370 CAD excluding VAT)**

To learn more about Hardsploit and follow the development

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Hardware & Software, Pentest, Audit, Training