RFID access control system, what it is and how to defeat it

Nemanja Nedeljkovic

RFID access control system, what it is and how to defeat it

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About me

- nemanjan00
- I like to take things apart
- Sometimes put them back togetger
- Reverse Engineering, RND and DevOps @ Constallation

About presentation

Scope:

- RFID credentials
- RFID readers
- Highlevel controller overview
- Integrator and manufacturers mistakes and problems

Out of scope:

- Magnetic tape
- Biometrics
- Plate recognition
- OSDP
- Business logic

Access control system

Card (ass grab tech)

Unique ID

- Different length
- Magic cards

Power supply:

- Active
- Passive

Frequency:

- LF (125kHz, 134khz)
- HF (13.56Mhz)
- UHF (300Mhz - 3Ghz) - Mostly for inventory systems, parking and tolls

Powering card - Electromagnetic induction

Current gets induced in one of these cases:

- Conductor moves in constant field
- Conductor is in alternating field

How is this used?

- Sinusoid signal at proper frequency (125kHz for example)
- Resonant antenna
  - Antenna length depends on wavelength (length light travels during one oscilation)
  - Lower frequency, bigger antenna

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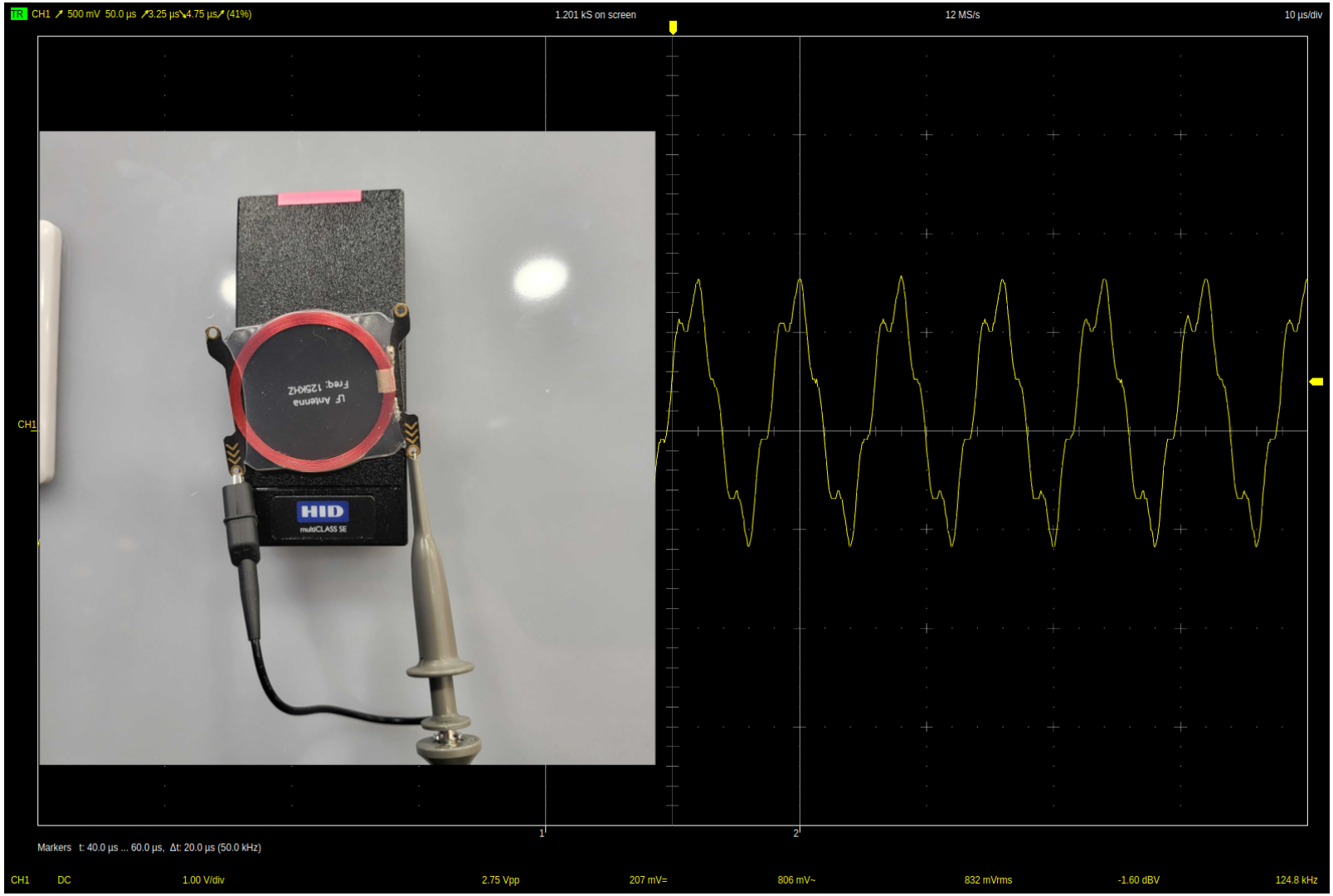
Powering card showcase



Command modulation - Reader to card

- Capacitor can be used to store power
- Sine cycles can be skipped, to modulate data (commands)

Data modulation - Load modulation - Card to reader

- Load on card = Load on power source
- Increase in load = Decrease in voltage
- It can be measured across both antennas
- It can be measured in field (sniffing)
- Switching load on and off can be used for modulation

Figuring out the frequency

- Flashlight (antennas do not look the same)
- Field detector

LF cards

- One-way communication or simple two-way communication
- Slow communication
- Mostly no security features
- Simple implementations
  - Modulation
  - Baudrate
  - Inverted

LF card standards

- HID Proxcard
- EM4100
- HiTag
- Indala

...

- T5577 can emulate other cards
- ISO 11784 / 11785 Standard - Animal chips

Vulnerabilities and characteristics

- Trivial to read
- Trivial to clone or emulate
- Requires big antennas for great performance, due to low frequency

Tools

Tool	Read	Write	Emulate	Note
Proxmark3	Yes	Yes	Yes	Steep learning cu
White cloner	Yes	Yes	No	No display for ID
Blue cloner	Yes	Yes	No	Sets password
Tinylabs Keysy	Yes	Yes	Yes	Closed source
Chameleon Ultra	Yes	Yes	Yes	Only EM4100 rig
Flipper Zero	Yes	Yes	Yes	Great support
ICopyX	Yes	Yes	Yes	Check emulation

HF cards

- Two-way communication
- Fast communication
- Very flexible in terms of features
- Quite a few standards, substandards and classes of standards implementations
- Some standards support anti-collision

Vulnerabilities and characteristics

- More advanced modulation techniques
- Proprietary communication protocols
- Sometimes encrypted
- Sometimes programmable (Java SmartCard)
- Readers do not always use proprietary features and sometimes rely on low level stuff like UID)
- Can be cloned, but relies on understandind the tech implemented in a card
- Higher frequency means smaller performant antennas = long range cloning (few 10s of cm)

HF card standards

RF communication: ISO 14443 A, ISO 14443 B, ISO 15693, ISO 18092

Application protocols: ISO 7816 (APDU) over ISO 14443 A/ISO 14443 B, Mifare Classic, Mifare Ultralight, ISO 15693 (NFC-V)

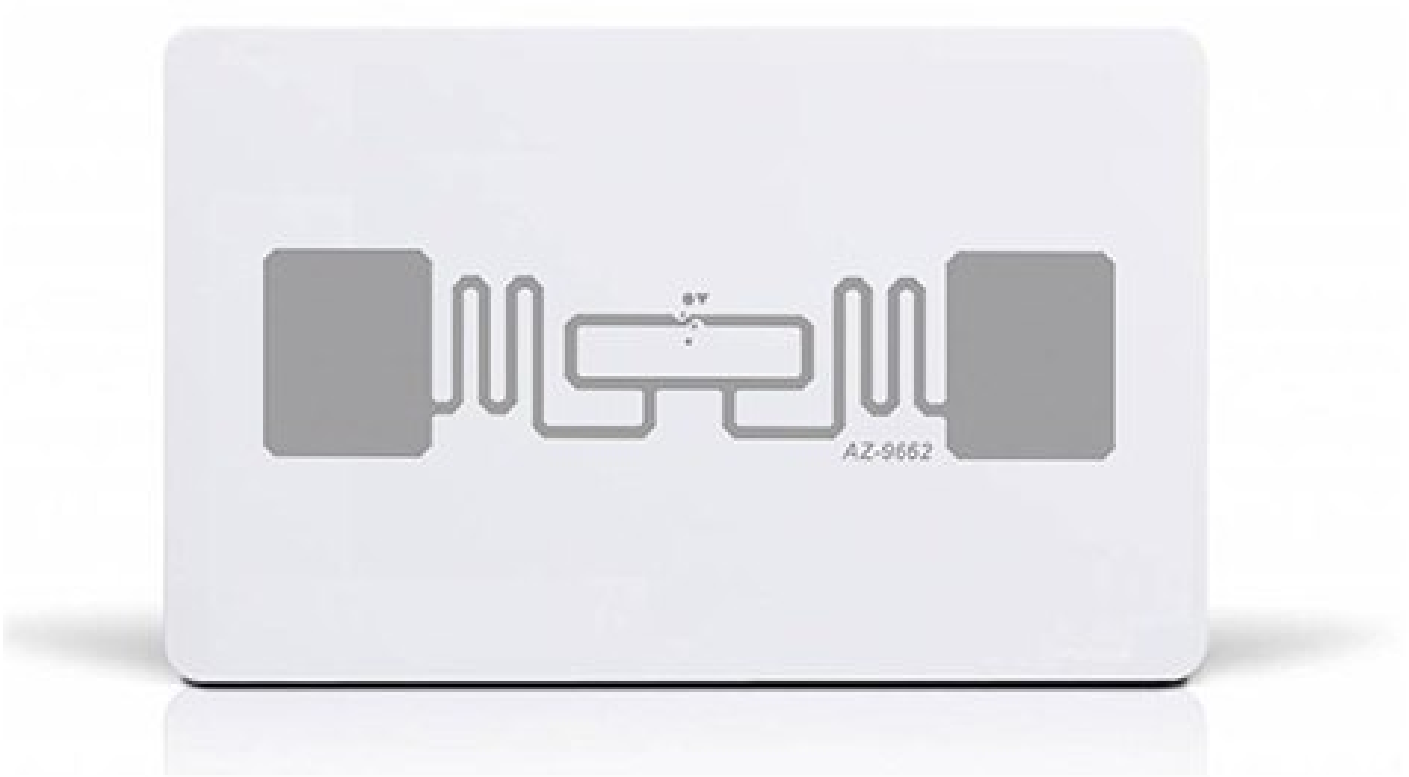
Implementations either extend existing command set or utilize ISO 7816 (APDU) over underlaying protocols.

Tools

Tool	Read	Write	Emulate	Note
Proxmark3	Yes	Yes	Yes	Timing issu
Chameleon Mini (Tiny)	Yes	No	Yes	Timing issu
Chameleon Ultra	Yes	No	Yes	Still too ne
Flipper Zero	Yes	Yes	Yes	Timing issu
Long Range Raders	Yes	Yes	Yes	10-20cm
PN532	Yes	Yes	Yes	LibNFC
DL533N	Yes	Yes	Yes	LibNFC

Type of card dependant

UHF cards



Controller

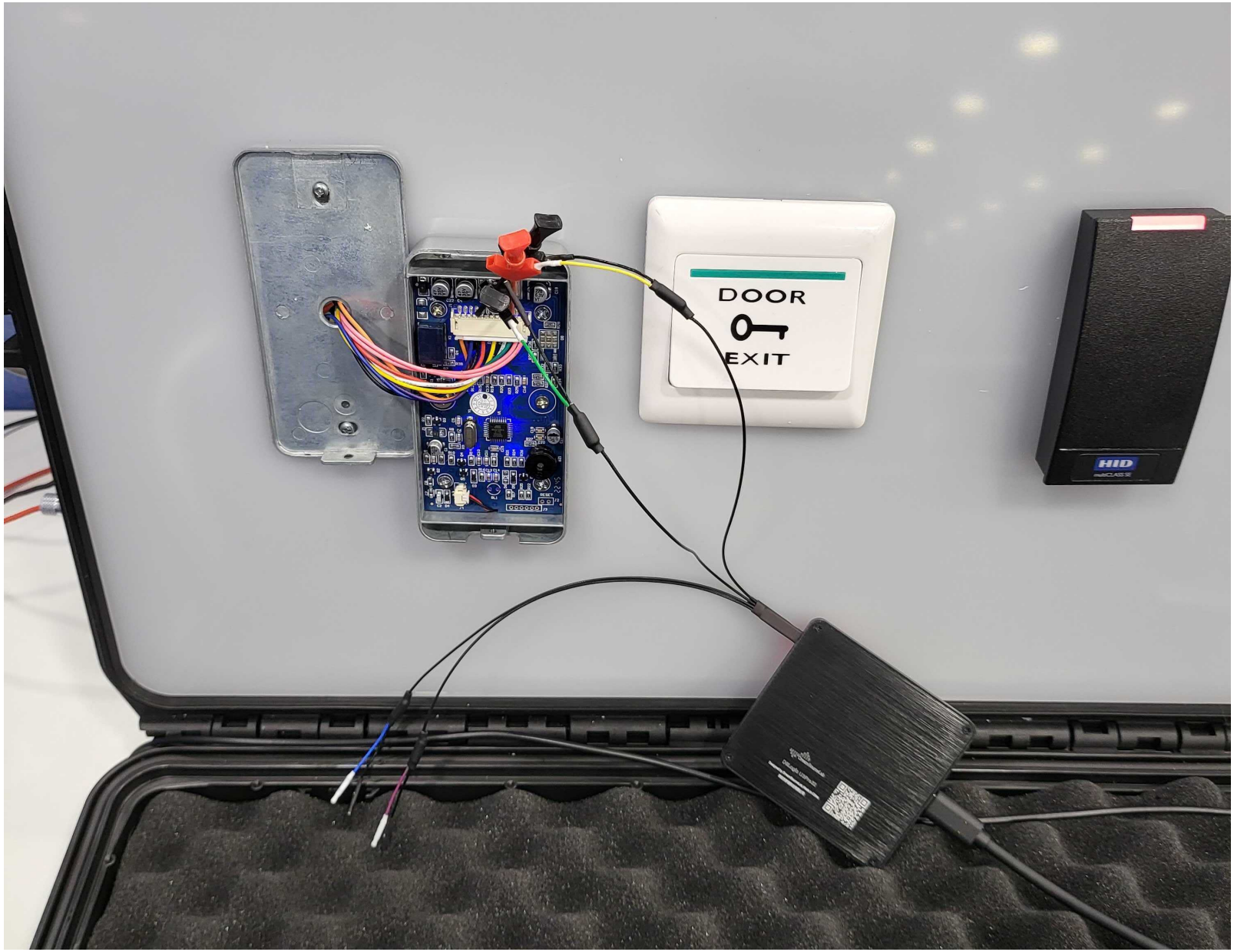
Input signal:

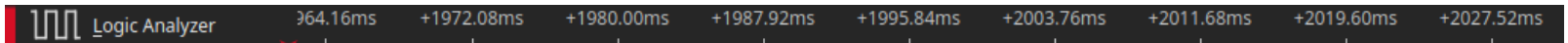
- Wiegand
- OSDP (out of scope)

Output signal:

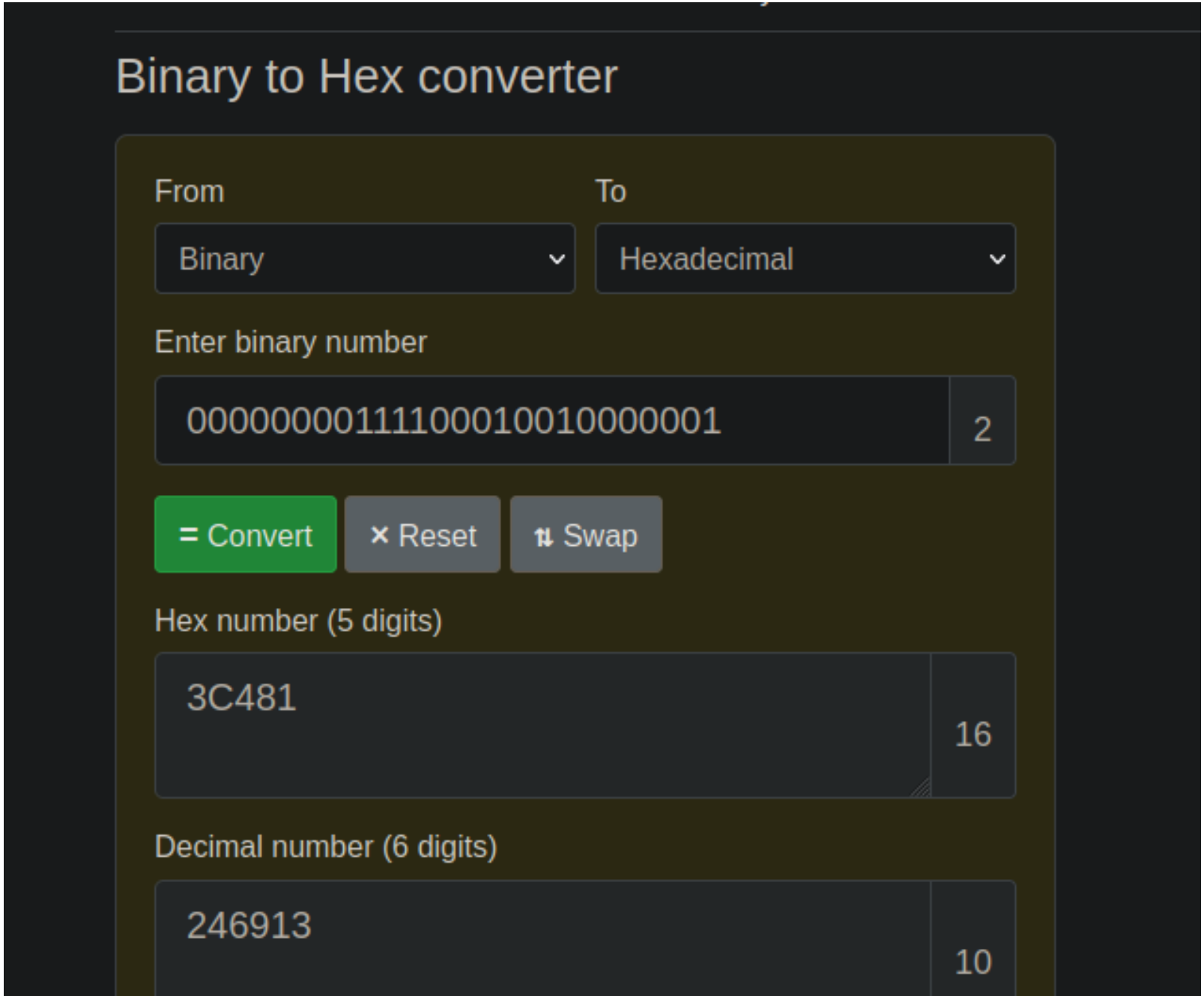
- Control the relay
- Audiovisual feedback

Wiegand


DOOR
EXIT
HID


Logic Analyzer
964.16ms
+1972.08ms
+1980.00ms
+1987.92ms
+1995.84ms
+2003.76ms
+2011.68ms
+2019.60ms
+2027.52ms

Wiegand to ID



Attacks

- Cloning credentials
- Hardcoded/default credentials
- Fuzzing attacks
- Downgrade attacks
- Crypto or PRNG implementation attacks (for example nested, hardnested and darkside attacks on Crypto1)
- Wiegand sniffing and replay
- Controller and reader combo attacks

Hardcoded/default credentials

- Some controllers come with default credentials hardcoded
- There are backdoor credentials
- Some of them have been leaked (No security by obscurity)

Fuzzing attacks

- There have been cases where readers did unlock for some extreme values
- 0x0000000000
- 0xFFFFFFFFFF

Controller and reader combo attacks

- Default password can be used to register new credentials
- Push to unlock button is on the outside
  - Signal wire is connected to VCC using pull up resistor
  - Button connects signal wire to ground
  - When voltage falls below certain value, relay is connected, to unlock
  - Color scheme for wiring is well known
- Relay is on the outside
  - Relay = Electromagnet connected to metal plate and metal plate on spring
  - External magnetic field can activate relay

Extra - Privacy concerns with UHF RFID cards

Product identification by GS1 standards

- UPC
  - Company prefix
  - Item reference number
- EPC
  - Company prefix
  - Item reference number
  - Product serial number

About the community

- Iceman Discord
- RRG Github