Universal Radio Hacker

A Suite for Analyzing and Attacking Stateful Wireless Protocols

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Proprietary wireless protocols everywhere

Smart Home

- Increase comfort through wireless sockets, door locks, valve sensors...
- Devices are designed under size and energy constraints
- Less resources for cryptography

Risks of Smart Home

- Manufactures design custom *proprietary wireless protocols*
- Hackers may take over households and e.g. break in without physical traces

How can we eavesdrop and manipulate the wireless communication between such devices to assess the security?

Software Defined Radio

Why Software Defined Radios?

- Send and receive on nearly arbitrary frequencies[a]
- Flexibility and extendability with *custom software*

[a] e.g. HackRF: 1 MHz - 6 GHz

(a) USRP N210

(b) HackRF

Software Defined Radios are affordable

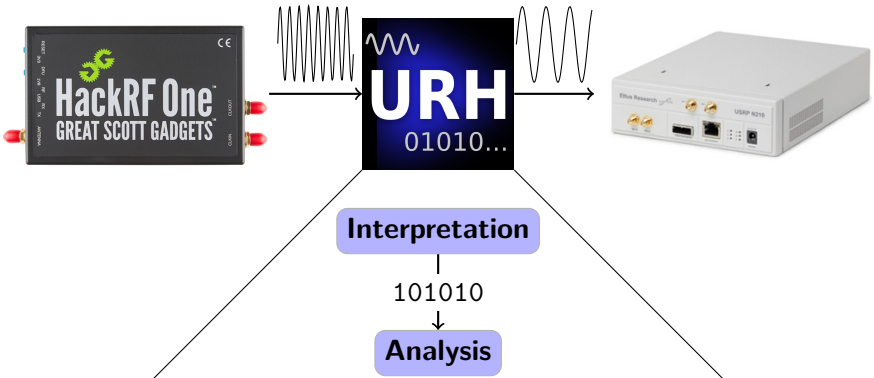
Last Checked: July 21, 2018

NooElec HackRF One Software Defined Radio (SDR)
by NooElec
$317.95 prime
Get it by **Wednesday, Jul 25**
FREE Shipping on eligible orders

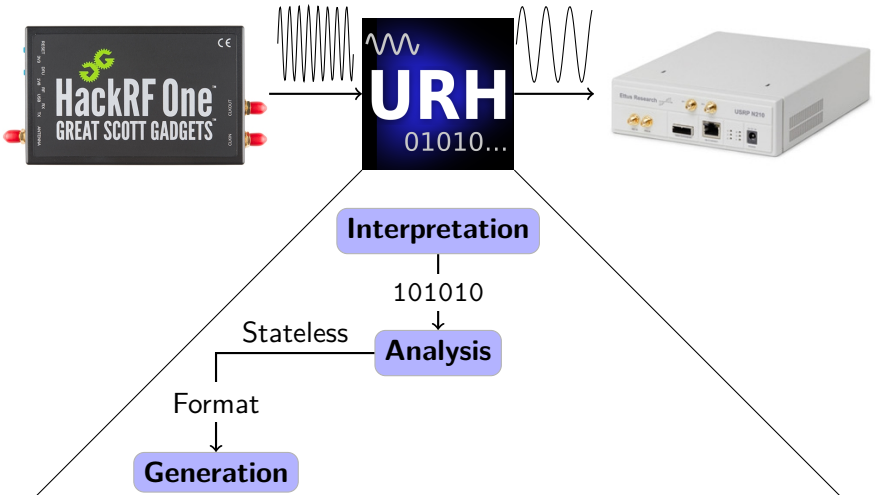
NooElec NESDR SMArt - Premium RTL-SDR Software Defined Radio
by NooElec
$23.95 prime
Get it by **Wednesday, Jul 25**
FREE Shipping on eligible orders

Universal Radio Hacker

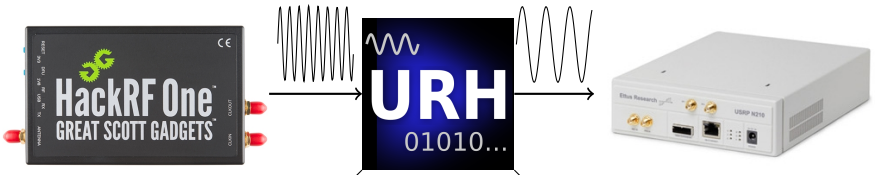
Universal Radio Hacker

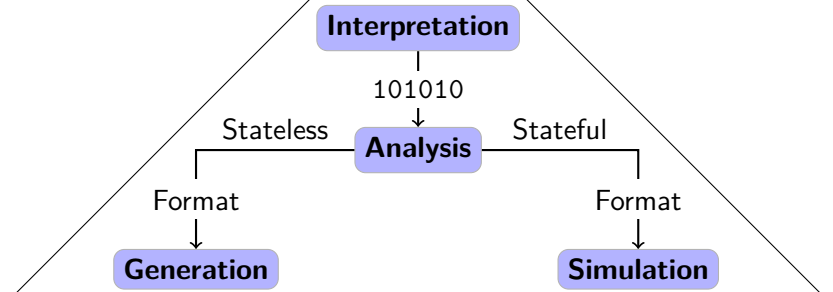


Universal Radio Hacker

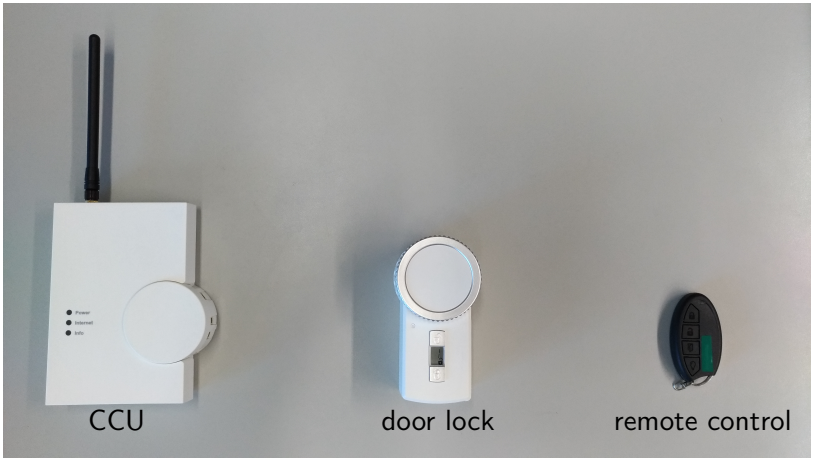


Universal Radio Hacker

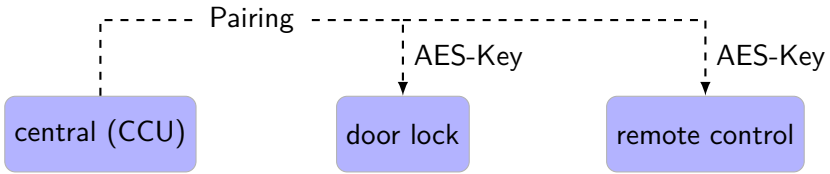




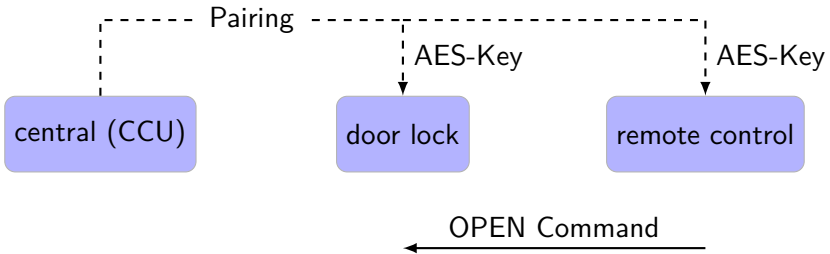
Setup



Overview


Pairing
AES-Key
AES-Key
central (CCU)
door lock
remote control

Overview


Pairing
AES-Key
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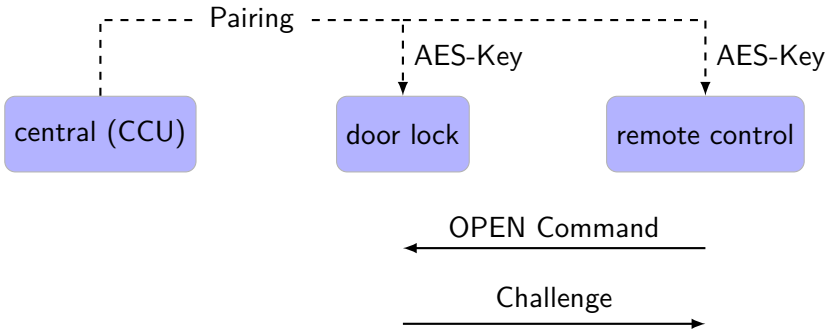
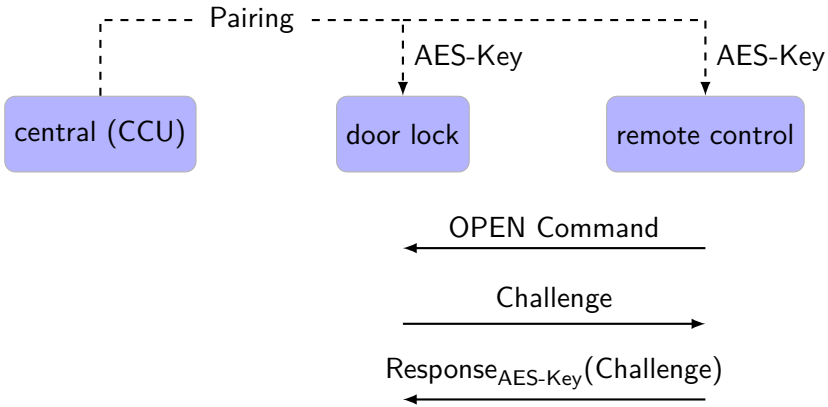
central (CCU)
door lock
remote control
OPEN Command

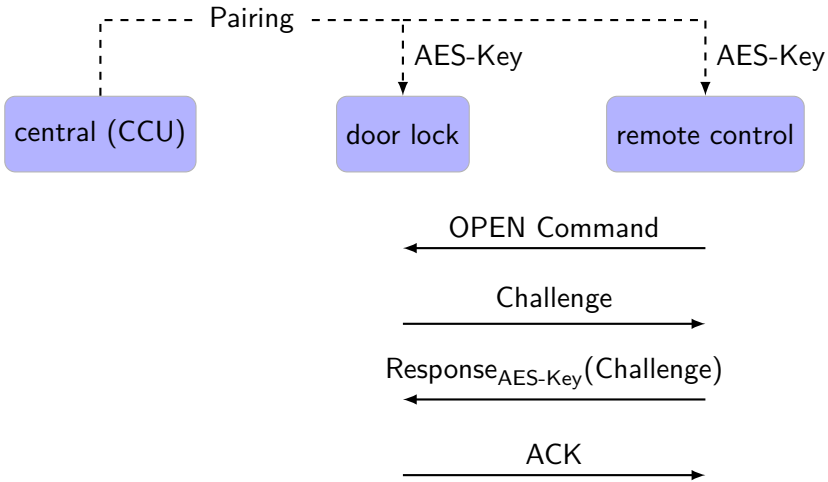
Overview


Pairing
AES-Key
AES-Key
central (CCU)
door lock
remote control
OPEN Command
Challenge

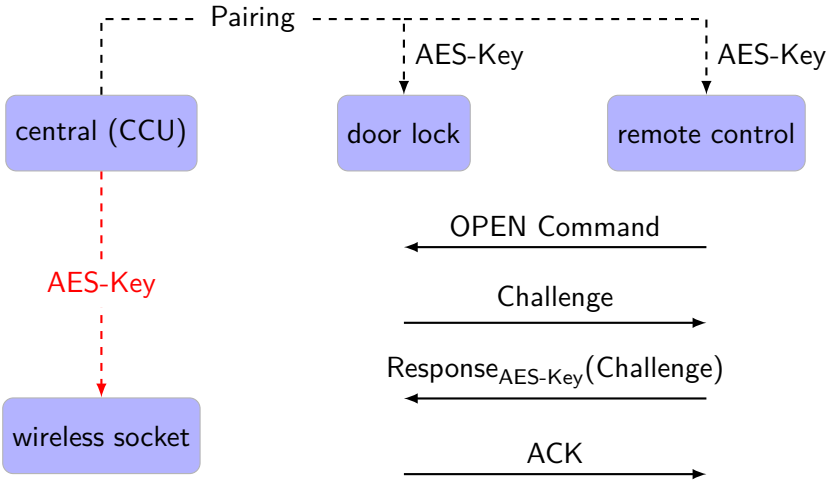
Overview


Pairing
AES-Key
AES-Key
central (CCU)
door lock
remote control
OPEN Command
Challenge
Response$_{\text{AES-Key}}$(Challenge)

Overview


Pairing
AES-Key
AES-Key
central (CCU)
door lock
remote control
OPEN Command
Challenge
Response$_{\text{AES-Key}}$(Challenge)
ACK

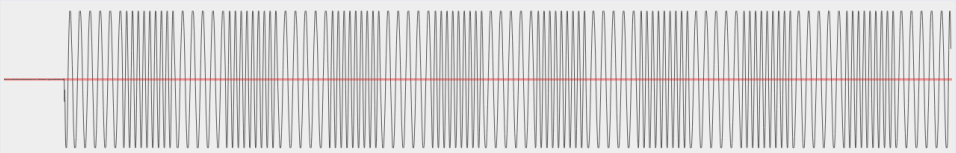
Overview


Pairing
AES-Key
AES-Key
central (CCU)
door lock
remote control
OPEN Command
AES-Key
Challenge
Response$_{\text{AES-Key}}$(Challenge)
wireless socket
ACK

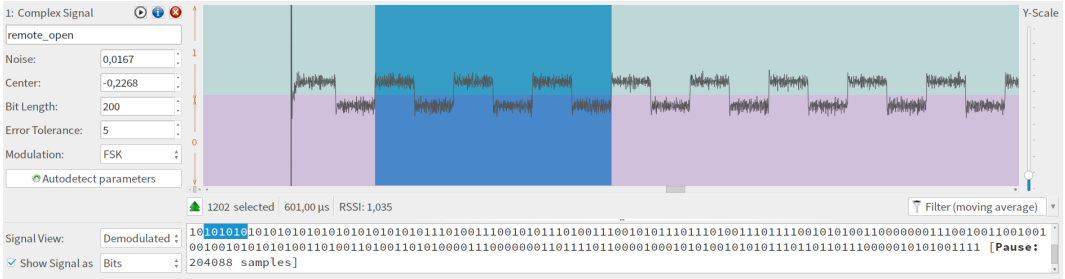
Record and demodulate signal

Capture of door lock open communication

Zoom into start of second message



Demodulation and Signal Editing with URH



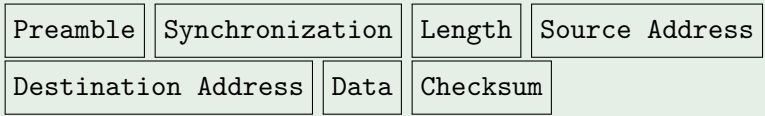
Further Interpretation Features

- **Synchronized selection** between demodulated and raw signal
- **Signal Editor** i.e. copy, paste, crop, mute signal selections
- Configurable moving average and bandpass **filters**

Analysis phase

In Analysis phase we reverse engineer the *protocol format*.

Example format



This includes

- **Decode** messages
- **Labeling** of protocol fields
- **Group** messages by assigning message types

What kind of decoding does the door lock use?

All messages are encoded in the following way

1. Pseudo encryption
2. Data Whitening
3. (Modulation)

Pseudo Encryption

Code

```
enc[0] = msg[0];
enc[1] = ~(msg[1]) ^ 0x89;
for(i = 2; i < NUM_BYTES; i++)
    enc[i] = (enc[i-1]+0xdc) ^ msg[i];
```

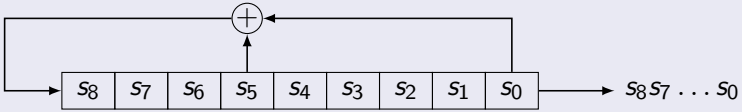
Use

- Does not increase the security
- Assumption: Obscure method for pseudo security

Data Whitening

Data Whitening

- To increase transmission quality a *data whitening* is used
- XOR with each 8 LSB of a pseudo-random sequence generated by an LFSR represented by the polynomial $x^9 + x^5 + x^0$

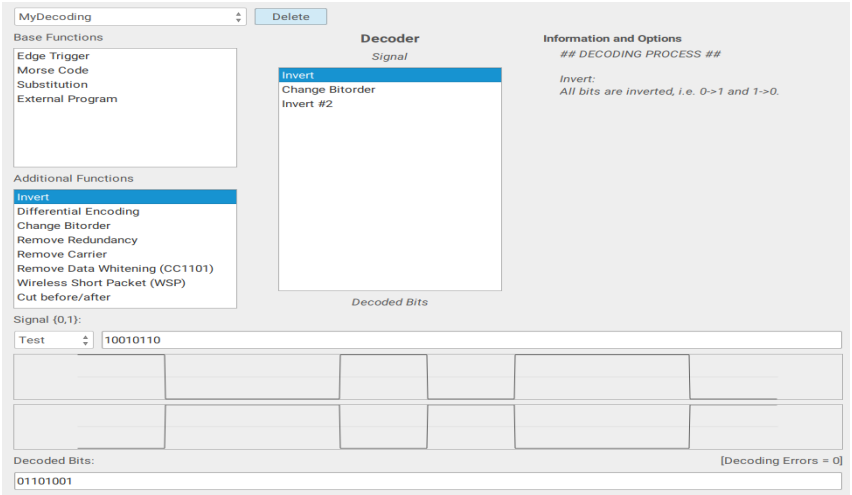


- Initial state is 111111111

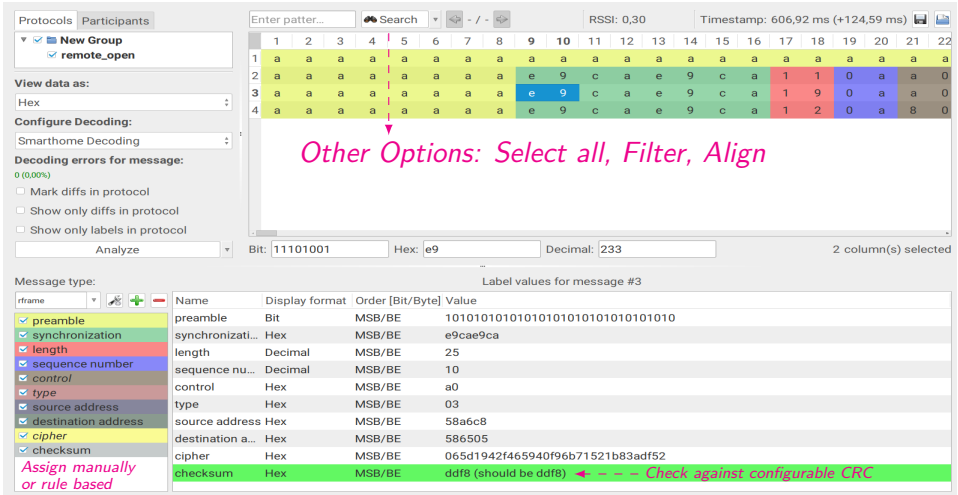
First eight states of the LFSR

111111111 $\Rightarrow$ 011111111 $\Rightarrow$ 001111111 $\Rightarrow$ 000111111 $\Rightarrow$
000011111 $\Rightarrow$ 100001111 $\Rightarrow$ 110000111 $\Rightarrow$ 111000011

Decodings with URH

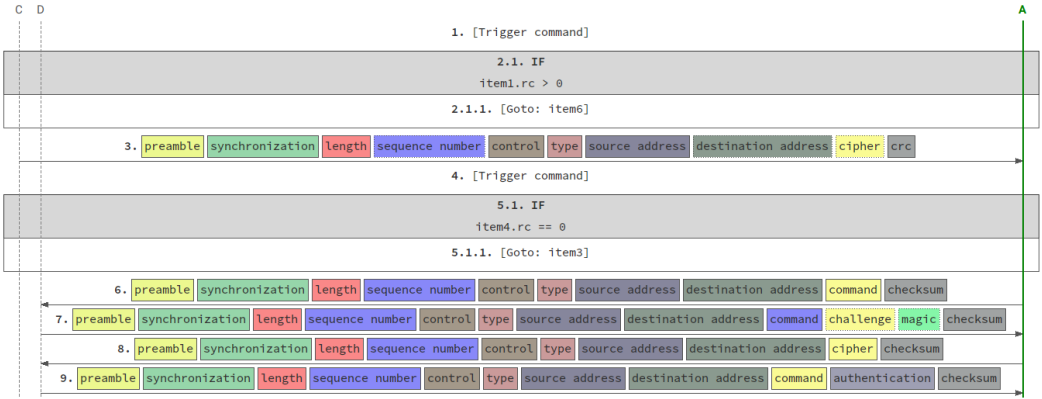


Result in URH after decoding and labeling



Simulation phase

In Simulation phase we can work on the logical layer. URH takes care of ***Modulation*** *and* ***Encoding*** *during simulation time.*



Demonstration Video

Summary and future work

Summary

- **Software Defined Radios** offer a high flexibility when investigating radio protocols
- Tools like **Universal Radio Hacker** abstract the required HF basics and enable analyzing such protocols without having to be a hardware expert
- Smart Home manufactureres have to react, Security by Obscurity is no longer an option

Ongoing work

- Rule based intelligence for automatic analysis phase
- Enhance accuracy of detecting interpretation parameters
- Support for more complex modulations e.g. 4-PSK

https://github.com/jopohl/urh

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