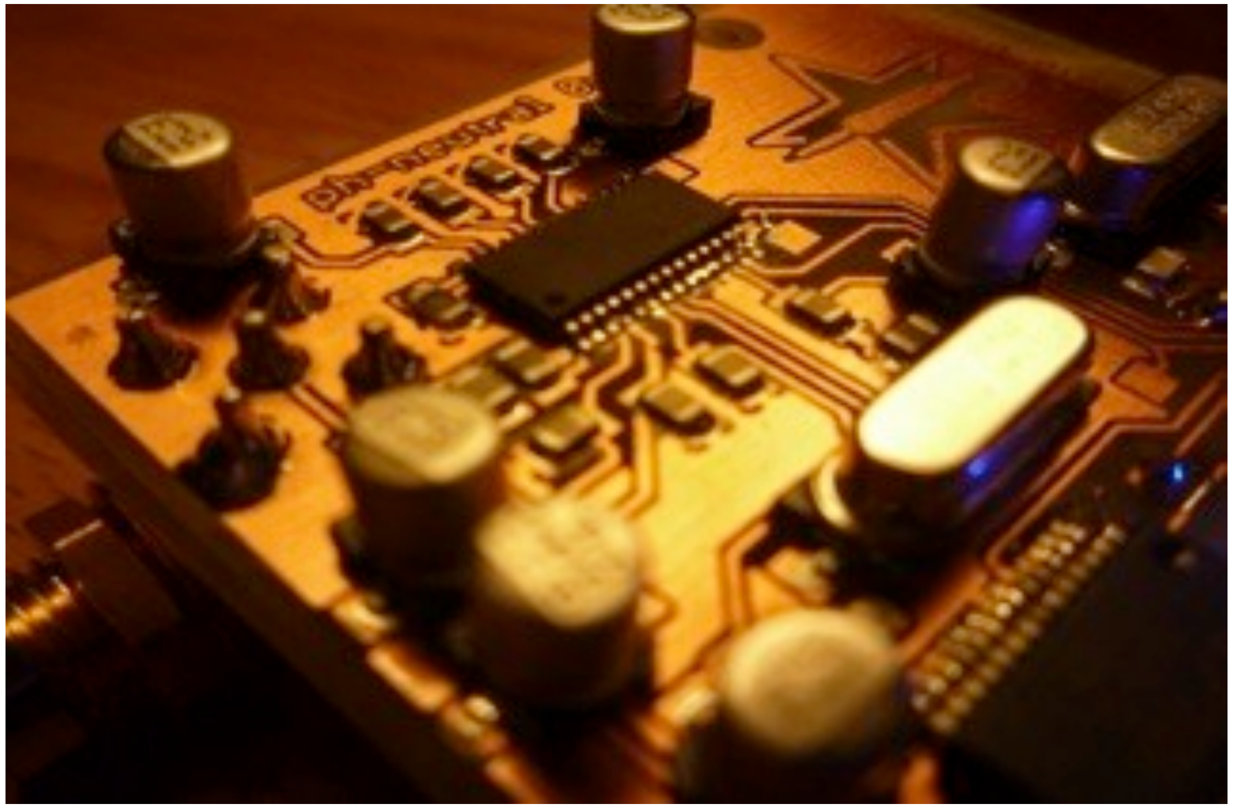
KeyKeriki - KeyKeriki - KeyKeriki - KeyKeriki - KeyKeriki - KeyKeriki

[k̟iːkəˑriˈkiː]

What Is This Talk About

27Mhz keyboards & analyzing RF Signals

Design and build an “Encryption Validation Device” aka known as keystroke sniffer with some special features



Warning!

- Verify the security of someone else's data transmission without permission could send you to jail in some countries :-)

About Us

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remote-exploit.org
<<back|track

Why Do We Continue Hacking This Stuff?

- Full disclosure
- POC technique was not usable in practice
  - Was neither portable nor handy
  - Depending on certain drivers and software (e.g. Sound card, filters)
- Going open-source
- Finishing the job :-)

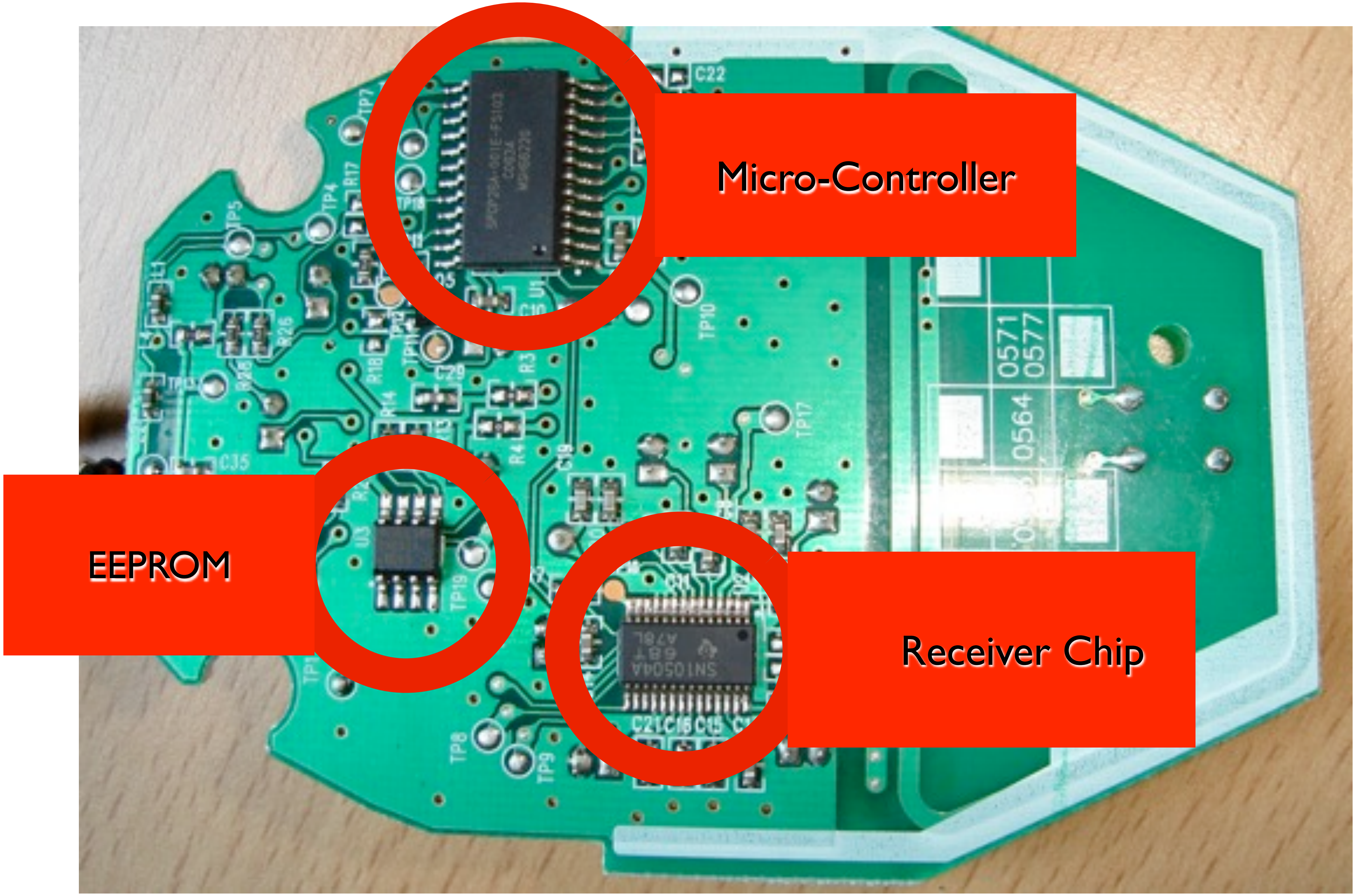
Technical Background

Involved Components

Receiver

- Receives, demodulates and processes the RF signal
- Most implementation are using dedicated receiver/transceiver chips to accomplish the demodulation task
- Micro-controller decodes data signal and generate the relevant USB-HID or Key scan-codes
- Persistently stores connection and encryption details

Microsoft Receiver



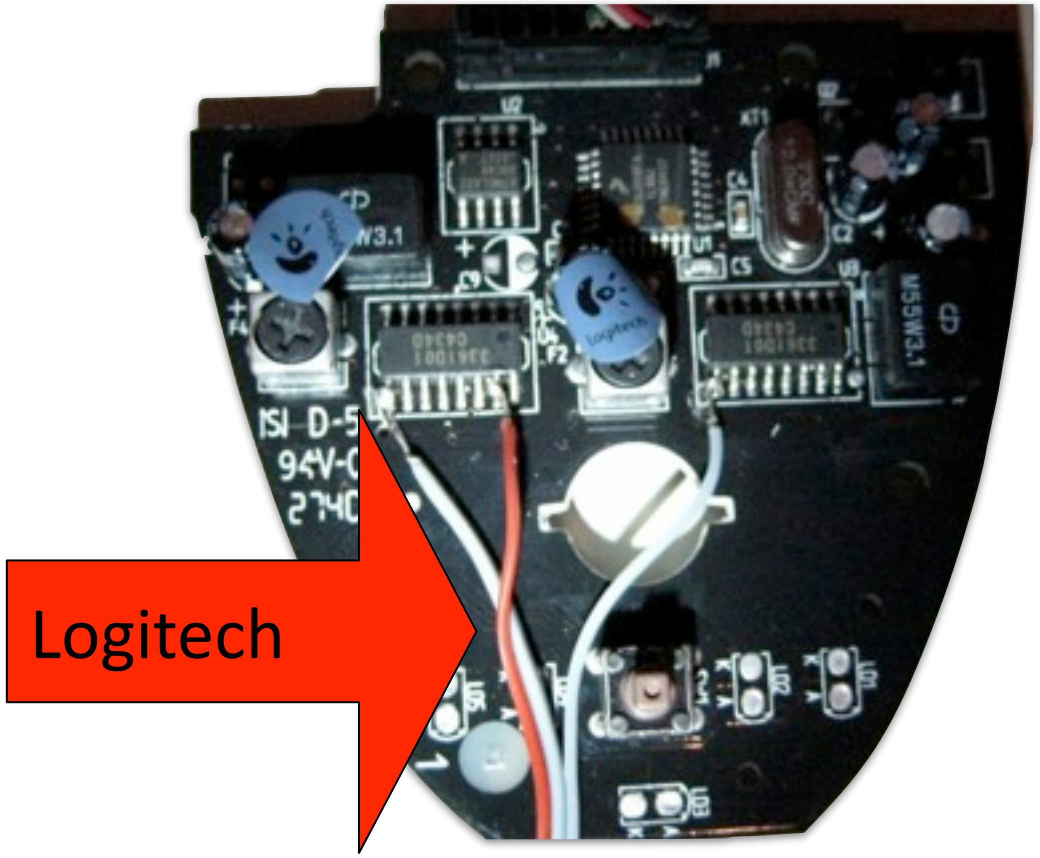
Micro-Controller

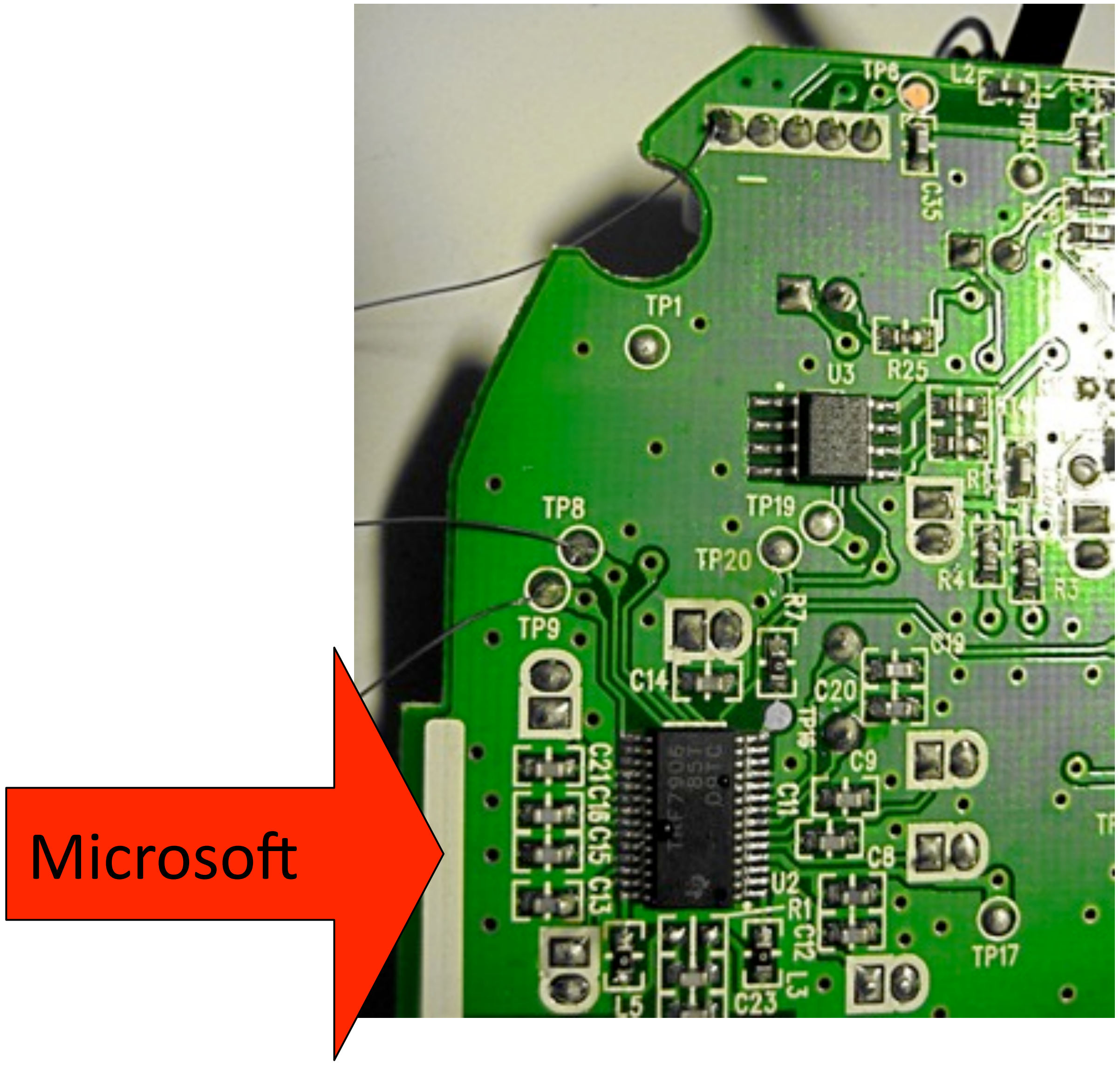
EEPROM

Receiver Chip

Sniff The Signal

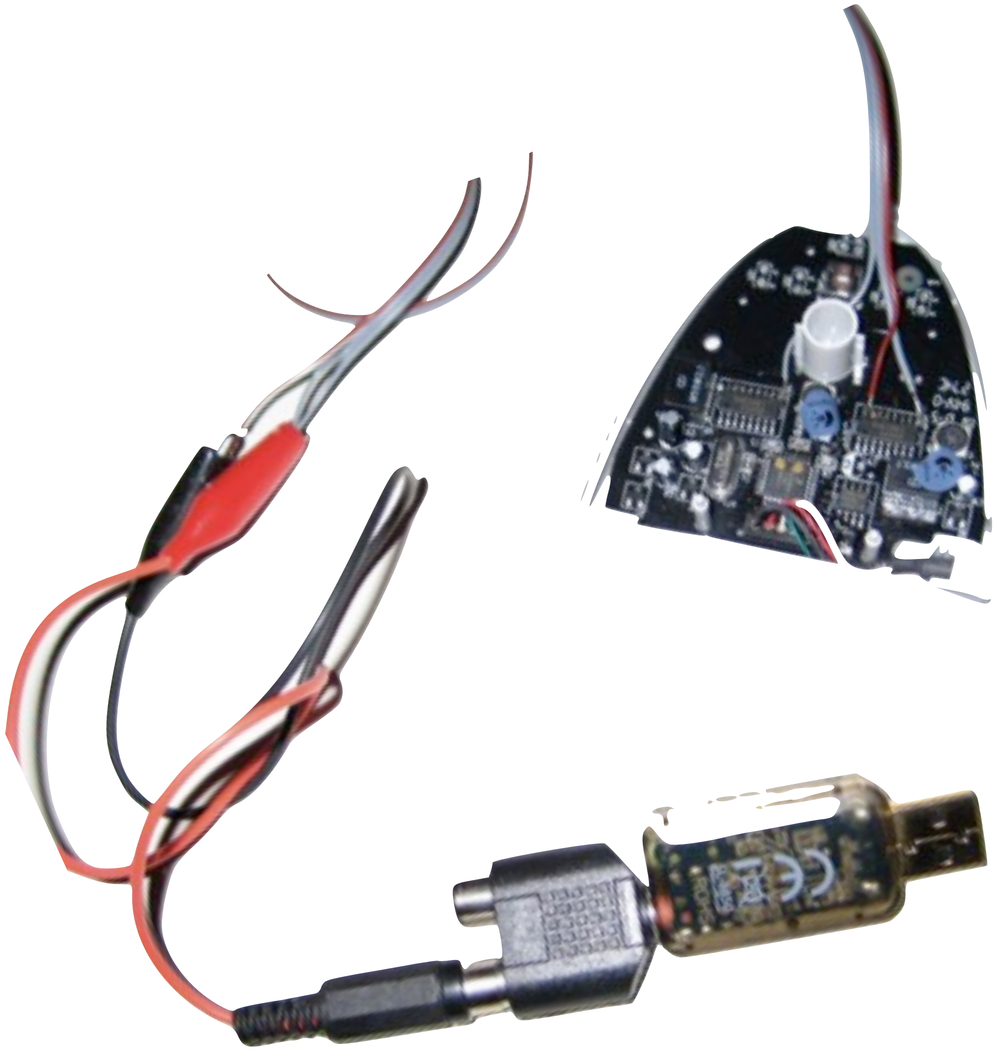
- RF scanner
- GNUradio / USRP
- Tap the original receiver
- Build your own receiver





Visualize The Signal

- Sound-card + Audacity (Soft-scope)
- (USB) Oscilloscope

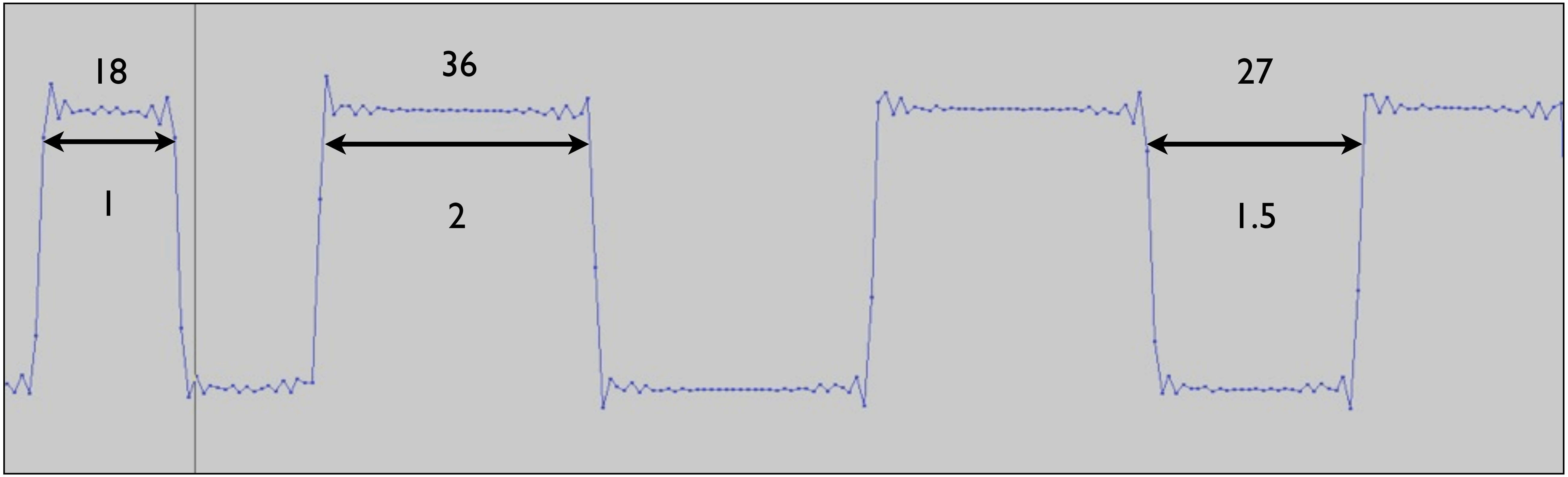


Identify Signal Encoding

- It is important to know how the binary data is modulated onto a signal
- Most communication is using standardizes ways to encode binary data
- There are a lot of well known methods available and even more variations of each
- NRZ, Miller and Manchester are some of the most common ones
- All keyboards we have analyzed where Miller encoded

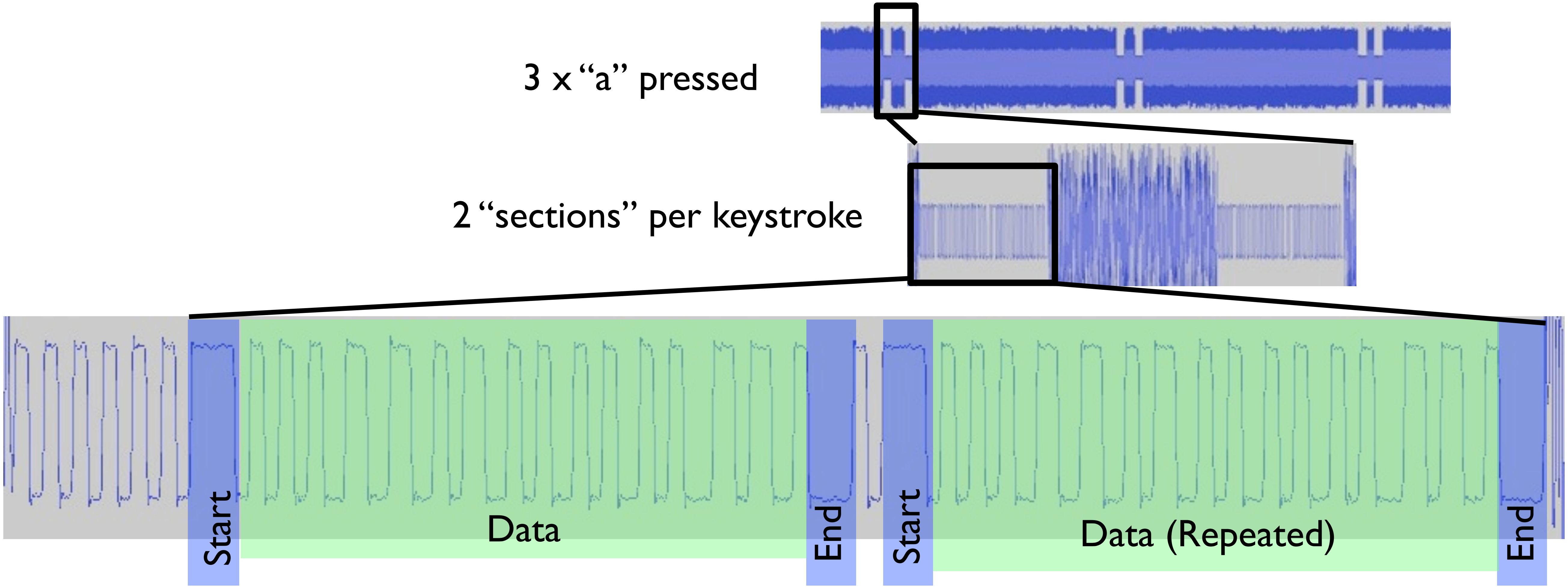
Miller

- Aka delay encoding - RFID, Serial RF protocols
- So a typical Miller signal has same signal level for a length of 1 bit period, 1.5 bit period and 2 bit period of time



Sequence Patterns

- Look at signals to find sequence boundaries
  - Do they repeat per keystroke?
  - Are they similar/identical when using different keyboards?

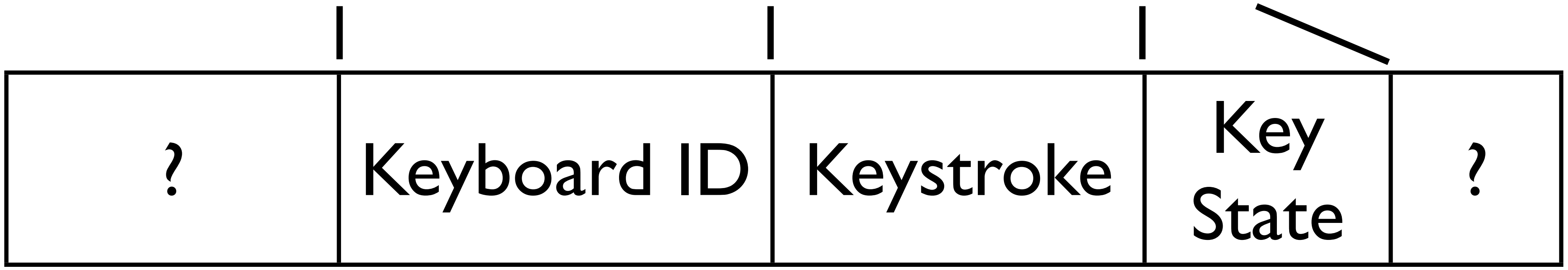


3 x “a” pressed

2 “sections” per keystroke

Data Details Logitech

a(down) Keyb 1	000000100	10001001001	0000011110	1	00000
a(down) Keyb 2	000000100	100111001111	0000011110	1	0001000
a(up) Keyb 1	000000100	10001001001	0000011110	0	00000
a(up) Keyb 2	000000100	100111001111	0000011110	0	0001000
b(down) Keyb 1	000000100	10001001001	0000000101	1	0101
b(down) Keyb 2	000000100	100111001111	0000000101	1	0100000
b(up) Keyb 1	000000100	10001001001	0000000101	0	0101
b(up) Keyb 2	000000100	100111001111	0000000101	0	0100000



?	Keyboard ID	Keystroke	Key State	?

Data Details Logitech 2

- Unencrypted per default
- Logitech drivers for windows are able to enable encryption
- Secure connect (new tech) has encryption on per default (Fixed identifier on RFID)
- Decoding not implemented in Keykeriki right now, but ready to be ported from first POC codes, just a value table lookup

Snipplet from lookup table

```
"0000111101"=>" ",
"0001110001"=>"[ENTER]\n",
"0001101001"=>"[SHIFTL]",
"0000110101"=>"[SHIFTR]",
"0000011101"=>"[CTRLL]",
"0000000011"=>"[CTRLR]",
"0000111011"=>"[WINL]",
"0001111011"=>"[WINR]",
"0001011101"=>"[ALT]",
"0001111101"=>"[ALTGR]",
"0000000111"=>"[WINMENU]",
"0001110010"=>"[TAB]",
"0001101110"=>"[CAPSL]",
"0000011110"=>"a",
"0000000101"=>"b",
"0000111001"=>'c',
"0000111110"=>'d',
"0000101010"=>'e',
"0001111110"=>'f',
"0000000001"=>'g',
"0001000001"=>'h',
"0001111010"=>'i',
"0000100001"=>'j',
"0001100001"=>'k',
"0000010001"=>'l',
"0000100101"=>'m',
```

Motivation / Threats

- „I forgot my bank officers password!“
- „Screen Sharing“
- Seriously…
  - Many public accessible offices with computers in front of customers are using wireless equipment to reduce the rat‘s nests onto the desk
  - Malicious people might want to collect passwords, CC numbers, PII, etc
  - Access to those desks is easy…

Getting Data Access

- Extending range using an antenna & amplifiers
- Get as close to the sender (keyboard) as possible
  - Souvenirs (Concealments)
  - Duck-tape
  - …

- No one throws them away

[redacted]

[redacted]

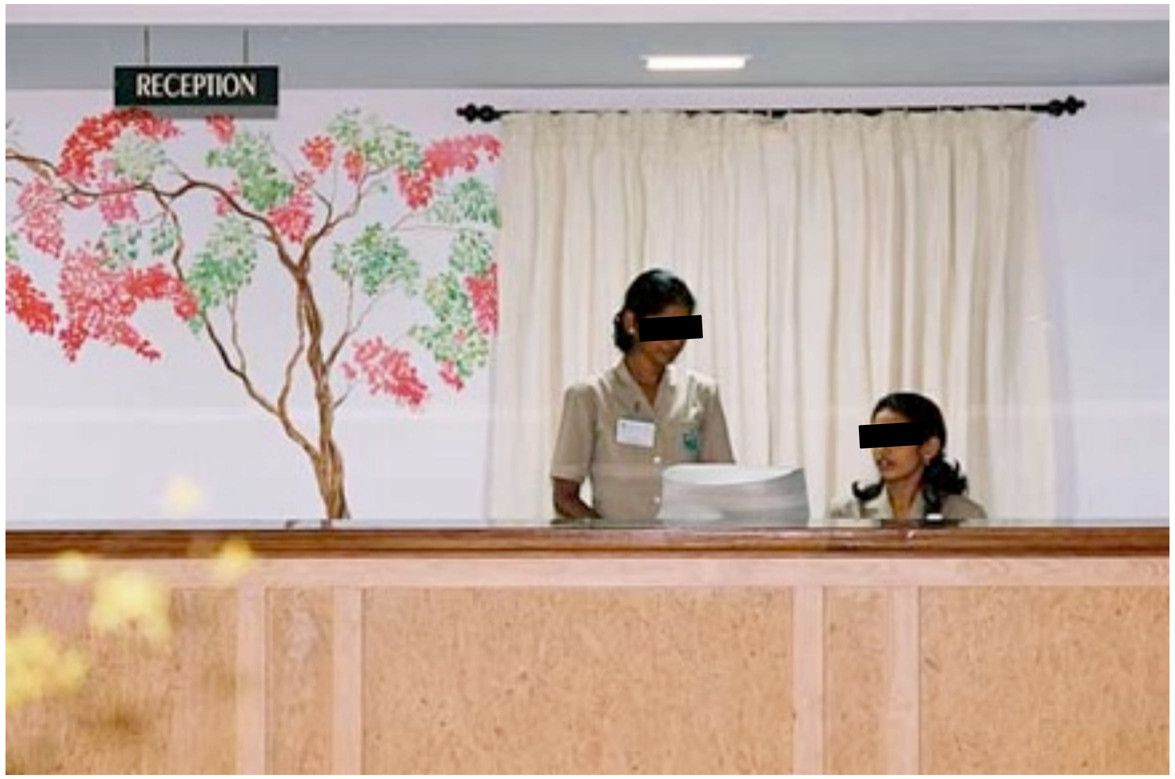
[redacted]

[redacted]

- Or just use some duck-tape and stick it somewhere

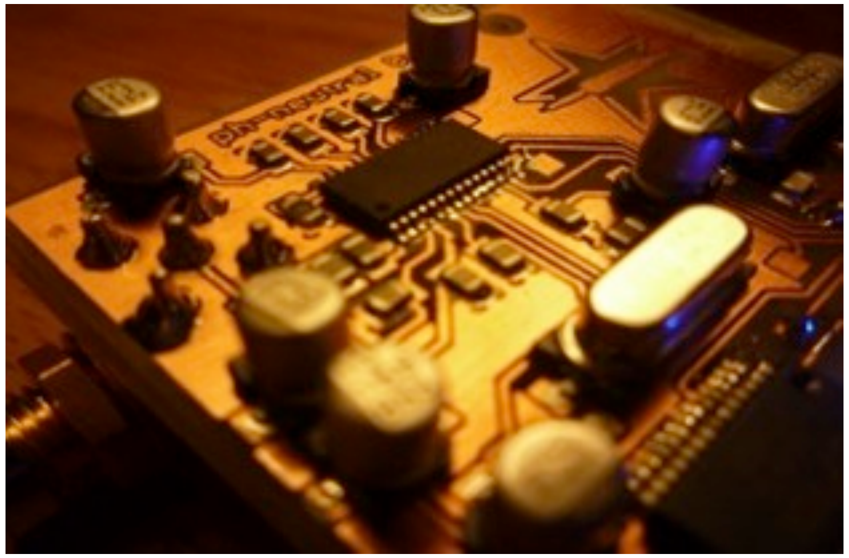
Getting Data Access

- Or simply make an appointment with the target person and keep it in your jacket



Design Considerations

- External antenna connector
- Small, Stand-alone / battery powered
- Platform / PC independent
- Data logging/storage desired
- Flexible interfacing with HW/SW extensions



The µC

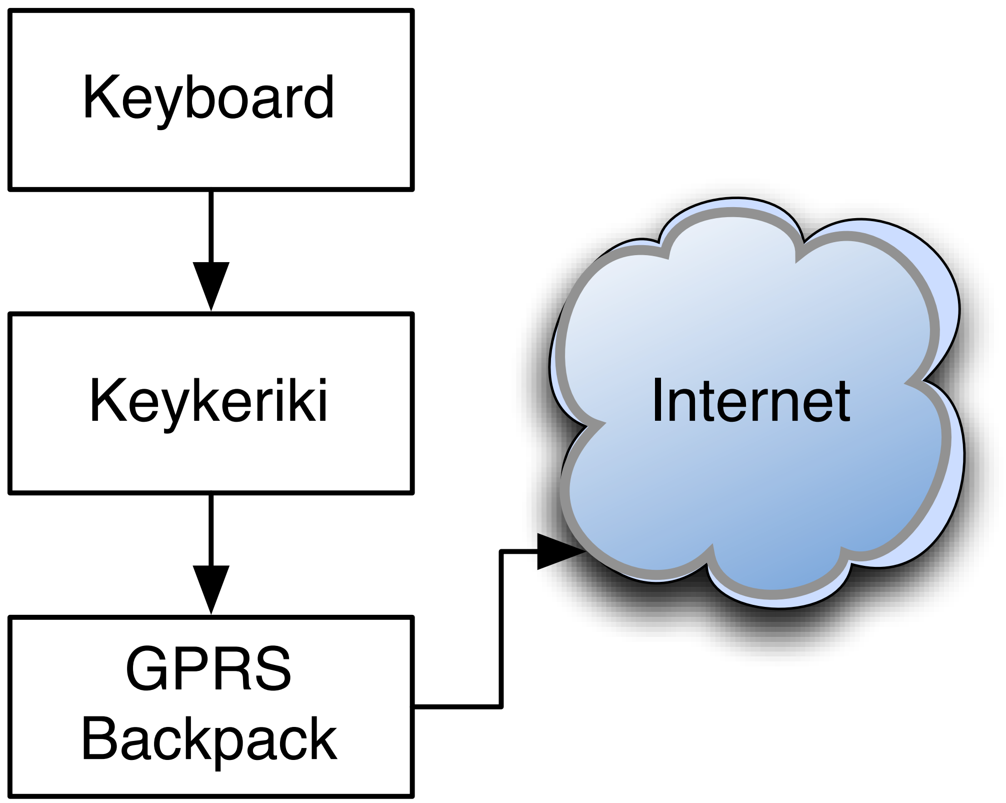
- Micro-controllers are small, cheap, handy, easy to use, less power consuming, …
- Programming is very easy (C, ASM)
- Hardware support for many useful items like detecting edges, timer, communication via different HW bus systems (I^2C/TWI, SPI, USART) etc
- Fast enough to compete with the user‘s typing skills (*)

(*) Timing

- Well, we have a lot stuff to be processed, we‘ll discuss some problems and limitations later

Tasks

- 1. Capture keystrokes
- 2. Decode keystrokes
- 3. Capture or crack crypto keys
- 4. Decrypt data and translate HID codes
- 5. Process and store or forward decrypted data



Task 1: Capture

- We can use different approaches to capture the signals using a micro-controller:
    - Using a input capture interrupt which detects falling or raising edges and interrupt code execution
    - Using two timers, we can act like an oscilloscope and measure times between edges as well as detect edges

Task 2: Decoding

- Once we captured the raw, digital signal, we have to decode it properly
- It‘s Miller Time!!
- But… Microsoft did some modifications to the miller decoding standard (surprise!)

Microsoft Vs. Miller

- Binary decoding depends on the value of the last decoded binary value. Depending on the variation it starts with “0” or “1”

Standard Miller		Microsoft’s Way	
Duration	Binary decoding	Duration	Binary decoding
1	1 bit (same as lastbit)	1	1 bit (**different** to lastbit)
1.5	1 bit “1” when lastbit == 0 2 bit “00” when lastbit == 1	1.5	1 bit **same** as lastbit and 1 bit **different** to lastbit
2	2 bits with values “01”	2	2 bits **same** as lastbit

More Pitfalls

- The packet sequence boundaries are **different depending on the type speed of the users typing-skills/speed!**

Task 3: Crack

- Store raw data and perform offline-bruteforce
- Gather current crypto key (XOR) in real time
  - Capture within keyboard SYNCH Sequences
  - Perform an On-The-Fly Cryptoanalysis and exploit design issues in the communication protocols

On-The-Fly Crypto Analysis??

- Freaking simple… For this release we followed and implemented two approaches:
  - Meta keys are unencrypted
    - If a Shift key is pressed, we go back in our data buffer and assume last typed key is a whitespace
    - Than we XOR the last data byte with the HID code for Whitespace and assume we have got the right key
    - We check if the key is correct by applying an XOR using the key to the previous byte. If the Plaintext equals an HID code of a sentence mark we assume to have the rigth key for the session

Crypto Analysis (Cont‘d)

- Second approach is to check wether a key is pressed three times in a row
- If so, we assume it was the HID code for the character ‚w‘ (i guess you are aware of the term „www“ ;-)
- After XORing the triple data byte with the HID code for ‚w‘ we assume to have the current XOR key
- We check if the key is valid by XORing the key with the next cipher-byte – if the result is the HID code for the character ‚.‘ we have successfully gathered a session key

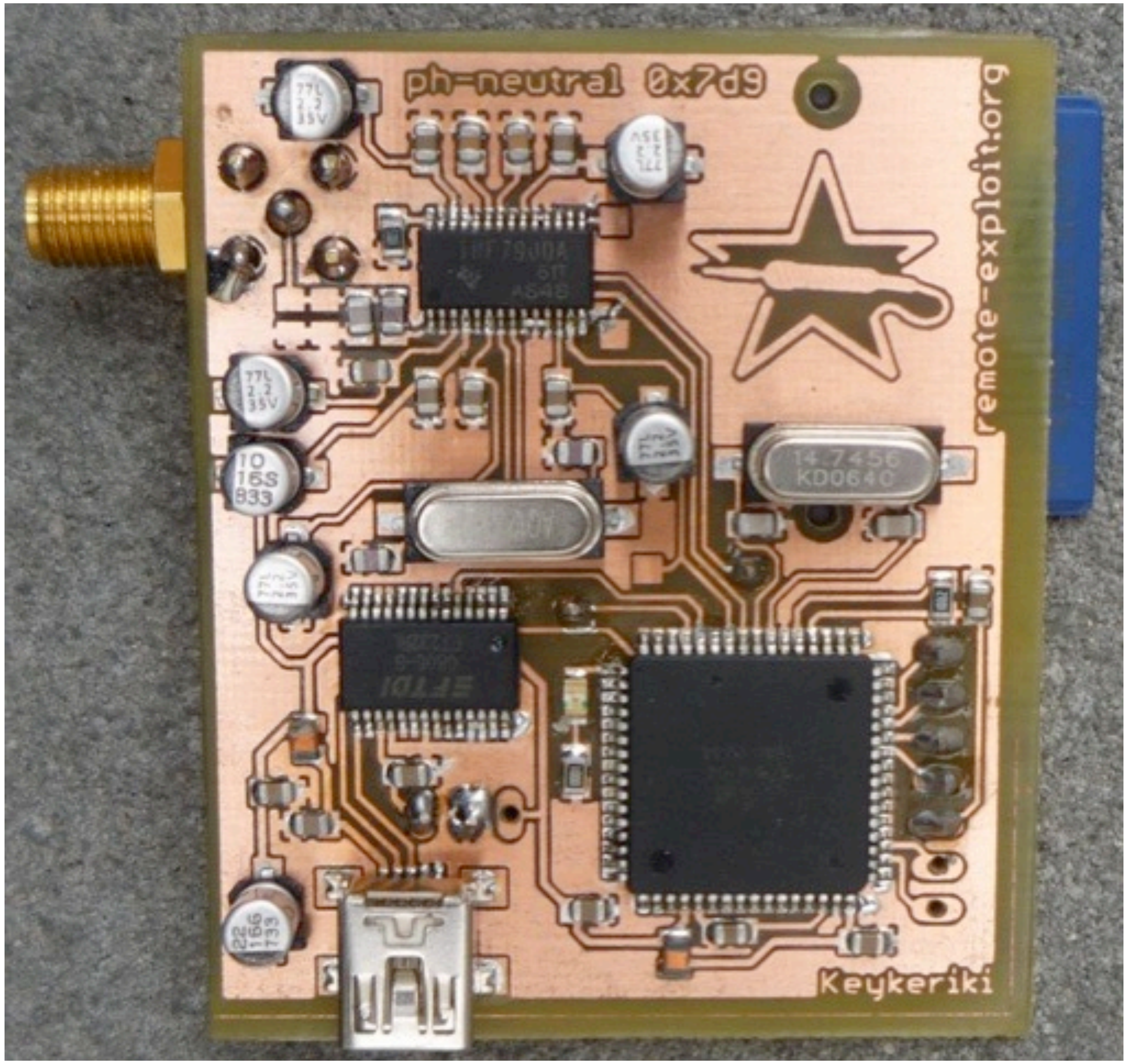
Task 4: Decryption & Translation

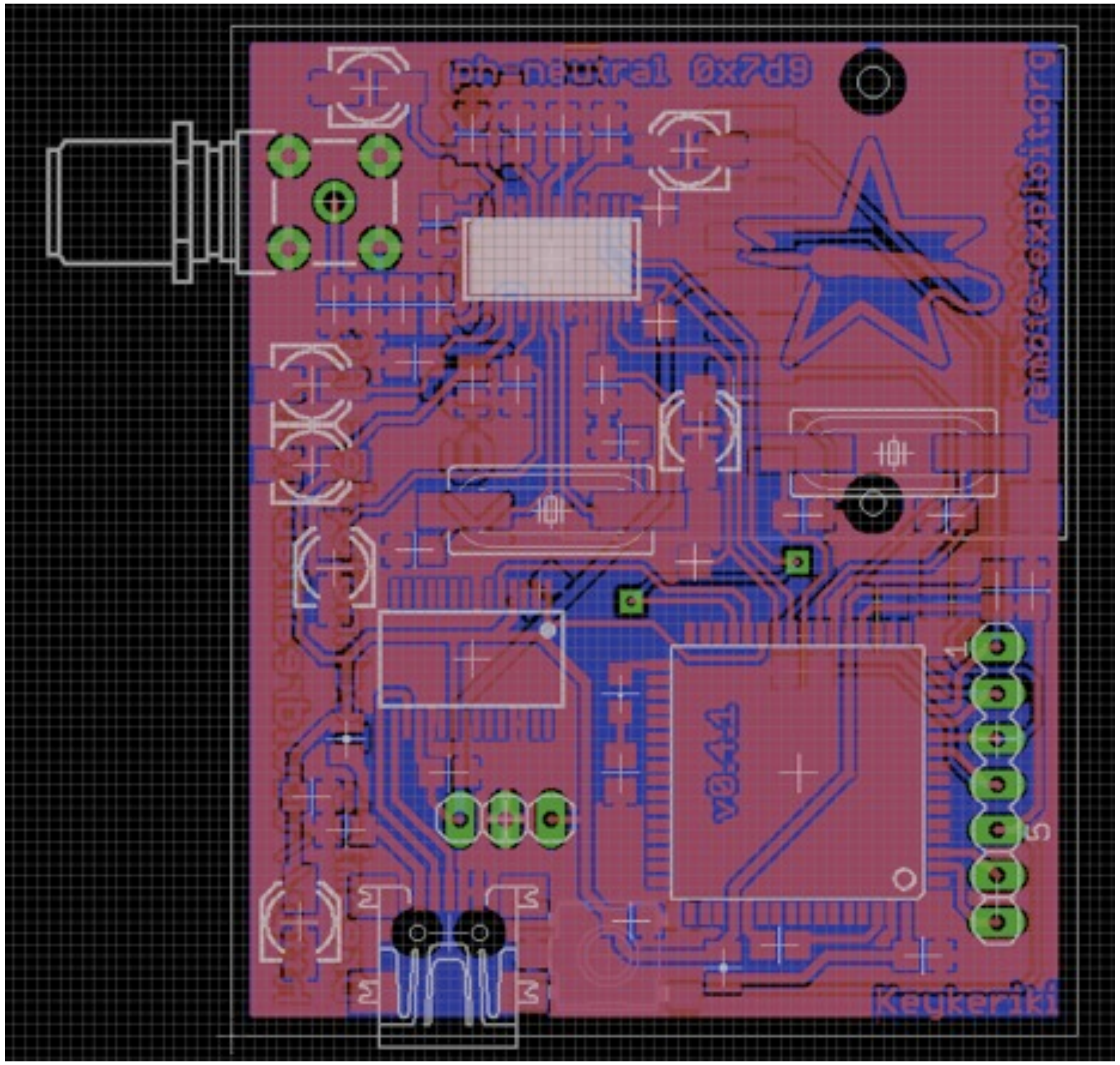
- After we have successfully gathered the Crypto Key, we can optionally perform an On-The-Fly decryption and translation of data
- Captured data is stored in raw mode as well as in deciphered mode
- Decrypted data can be used to be displayed on a small LCD screen or on a computer (via USB)

Task 5: Process & Store

- Data is written to the SD Card in Raw and Plaintext
- Text data can be transfered to an LCD display
- Data can be send to a computer via USB cable (no special drivers necessary, our device works well with default FreeBSD, Mac OSX, Windows XP, Vista, Linux, maybe IPhone(*) …) ☺
- We can also send data (buffered or unbuffered) via USART to a cellphone which has an SMS flat-rate or GPRS

Our HW Solution





Atmel Atmega 64

- Pro's
  - Cheap
  - Flexible, easy to handle, well known
  - Built-in features meet our design considerations
  - Pin & footprint compatible with larger microcontrollers when more memory is required

Atmel Atmega 64

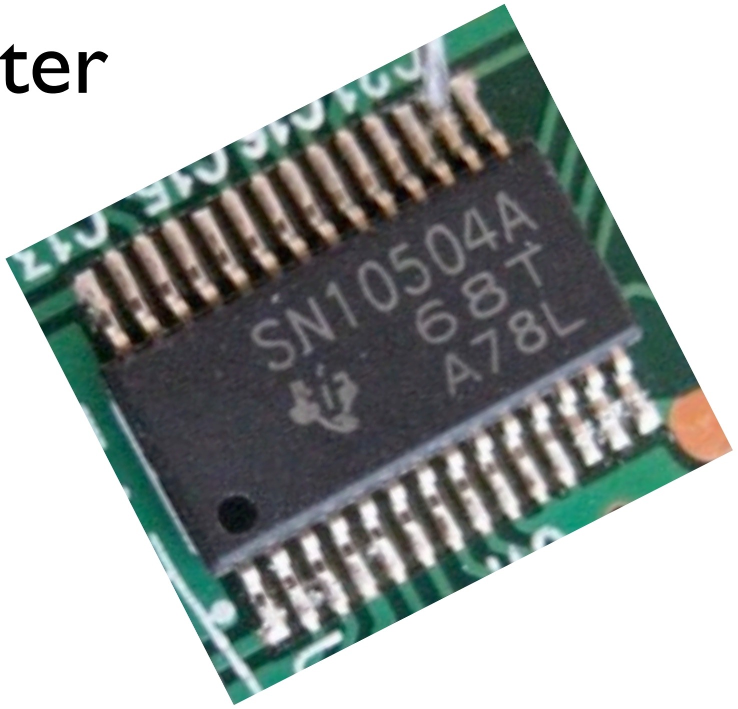
- Con's
  - 8-bit only
  - Limited amount of resources
  - Small pitch (TQFP 64) makes it difficult for beginners to handle

TI TRF7900 Receiver Chip

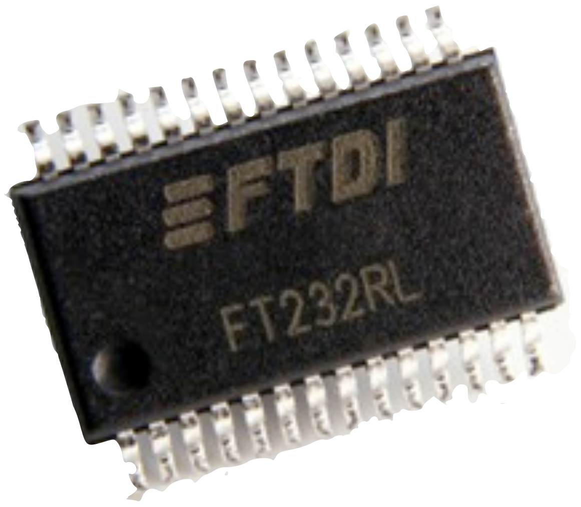
- Pro's
  - All in one IC solution
  - Can handle all commonly used frequencies
  - Able to be configured using I2C bus
  - Built-in Signal Strength Measurements (RSSI)
  - Dual channel capable
  - Relatively cheap
  - Low power cosumption

TI TRF7900 Receiver Chip

- Con’s
  - Differential antenna input with 5kOhm input impedance
  - Public documentation could be better
  - 5V only



FTDI FT232RL



- Pro’s
  - USB to RS 232 converter
  - Driver included within all major os ‘s
  - Supports USB bus powered design
  - Integrated 3.3v regulator output
  - Bitbang modus
  - Open-source code available from vendor
- Con’s
- Relatively expensive

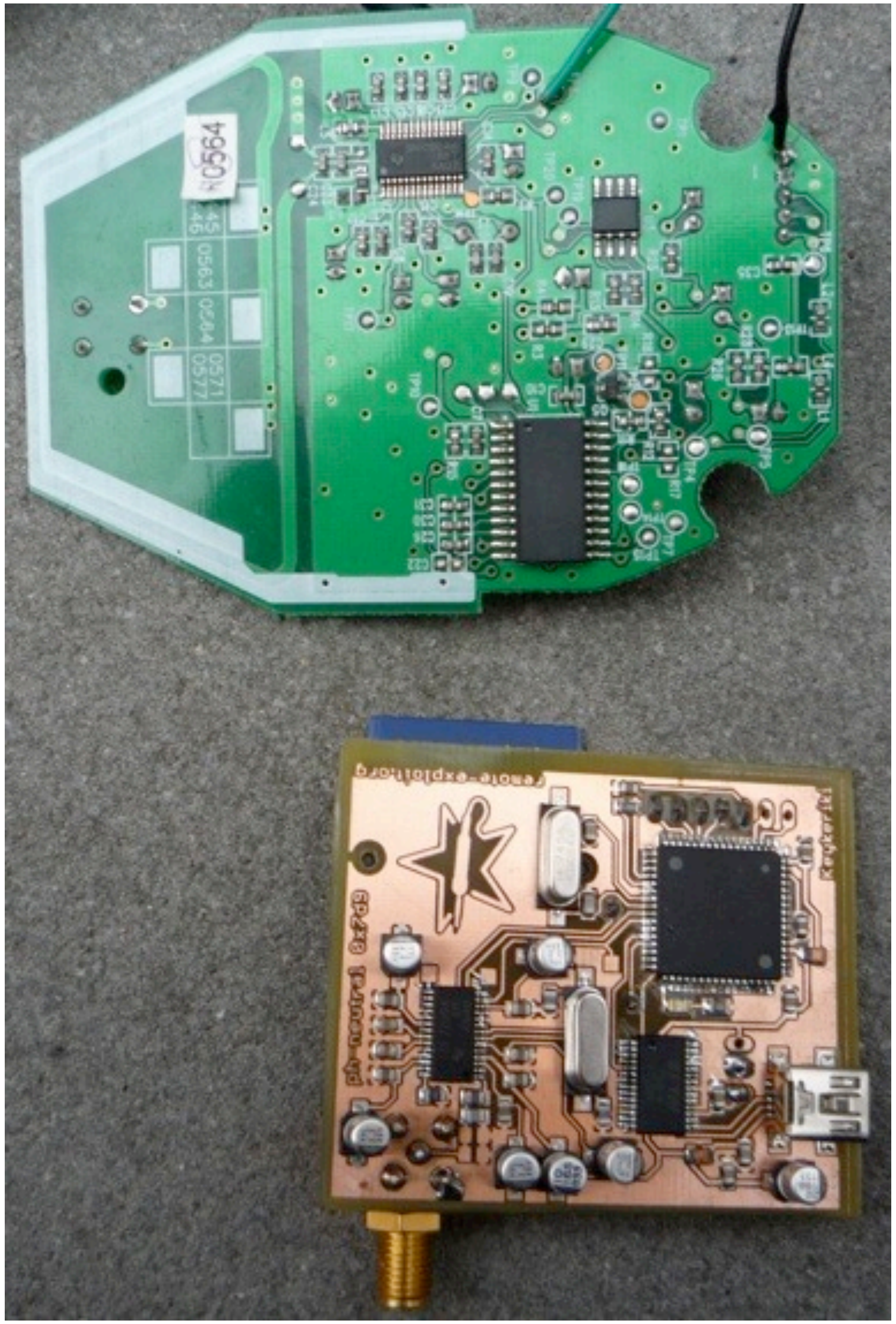
SD Card

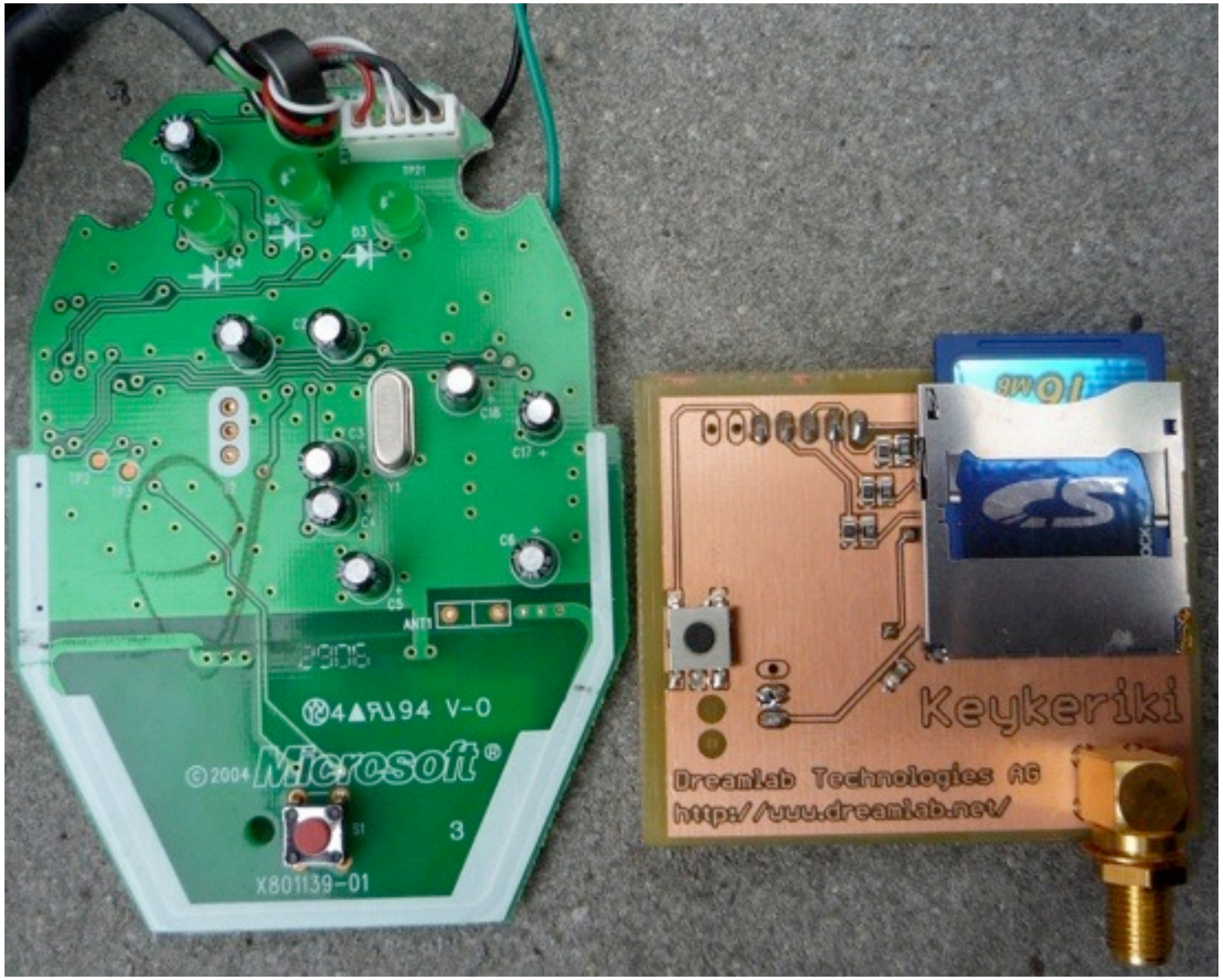
- Pro’s
  - Cheap
  - Larger storage capacity
  - Easy to use compared to other storage types
  - Requires very few external components
  - Standard SPI bus used for communication
- Con’s
  - 3v only!

External Antenna Connector vs. PCB Loop Antenna

- Pro’s
  - Arbitrary antennas
  - Larger receiving range
  - Smaller
- Con’s
  - Directional antennas would be very very very large (27Mhz ~= 11 Meter)
  - Expensive

Original Receiver Vs. Keykeriki

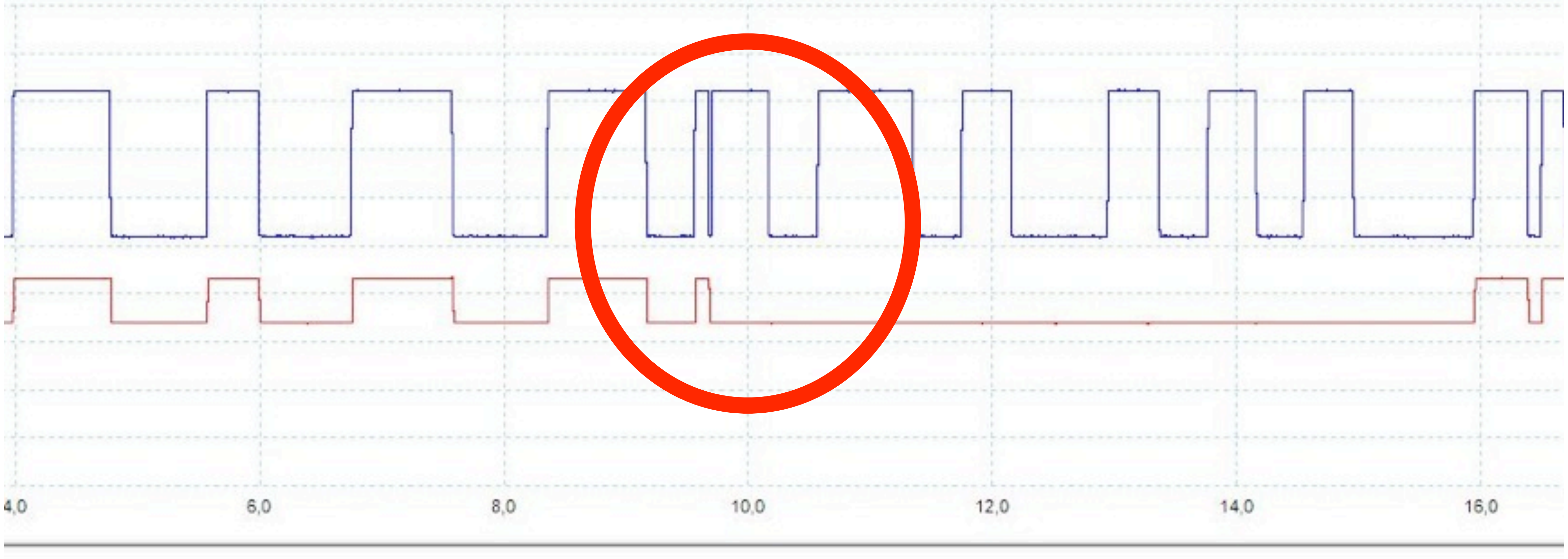




Worth To Be Mentioned Pitfalls

Problem Error Correction

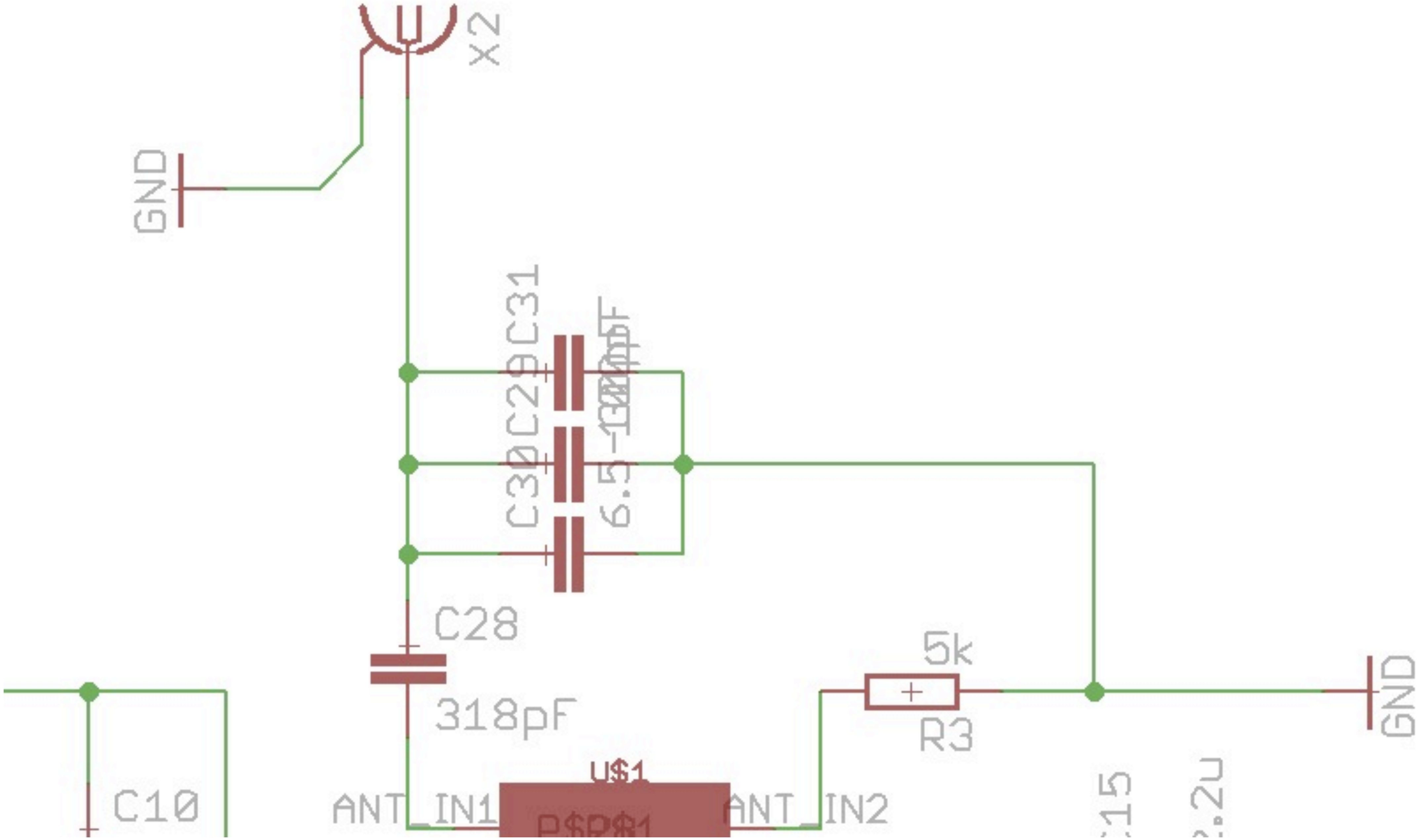
- Input capture is not optimal for error correction
- Error propagation to later part of decoding
- Errors in Start/Stop patterns are hard to distinguished from noise



Problem Antenna Matching

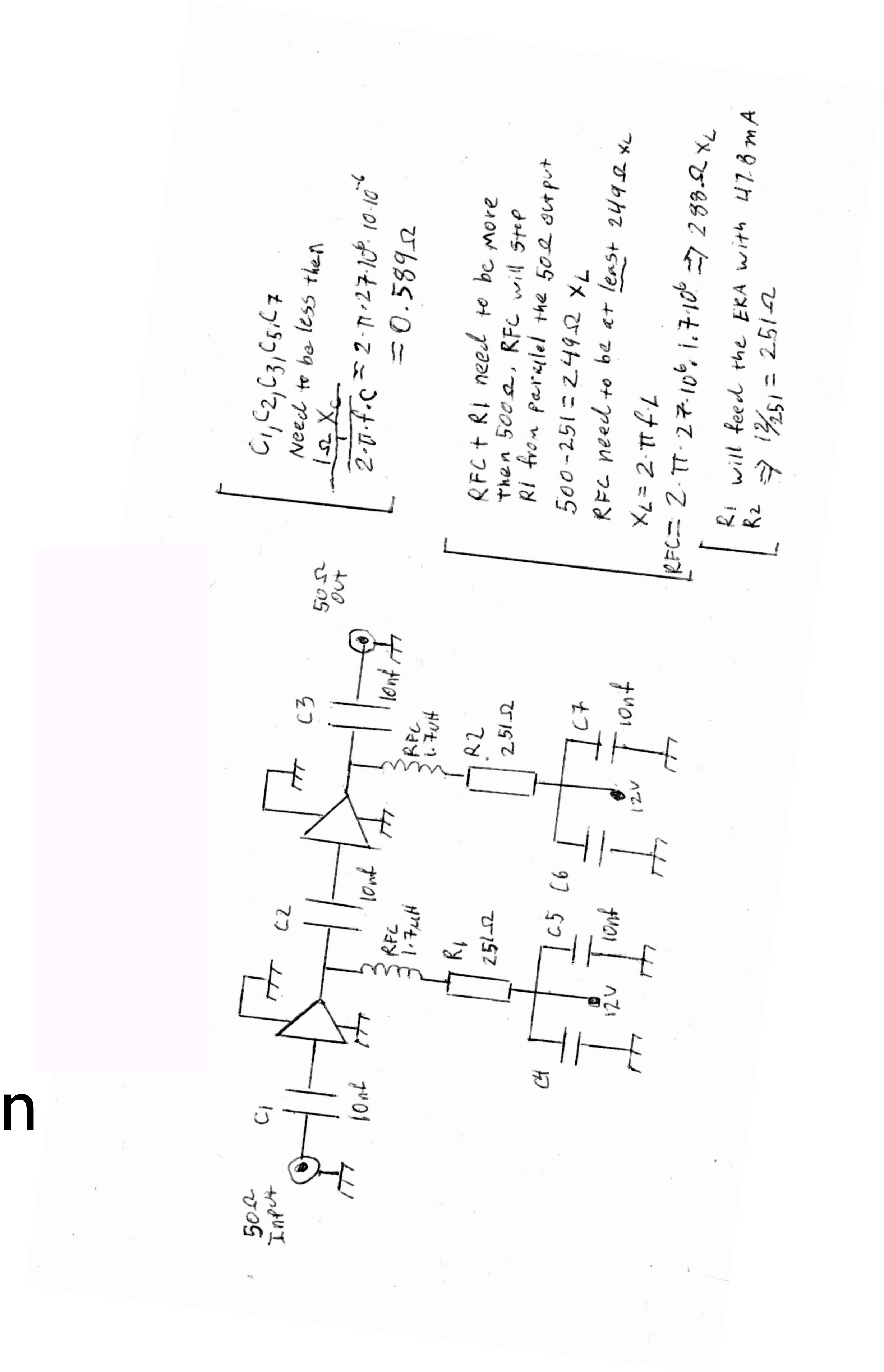
- Design recommendations available for differencial loop pcb antennas
  - TI: “Unfortunately we did not make any such design”
- TRF7900 Chip got 5kOhm input impedance
  - Common CB (11 Meter) antennas have 50Ohm
  - Hughe gap! Small solution is needed
  - Proper balun + match difficult in that size footprint

Current Antenna Matching



Future

- Keystroke injection
- Range extension using amplification
- Port Logitec decoding to Keykeriki
- Automatic channel-hopping, Kismet-NG Plugin?
- Analysis of Logitec encryption
- Decoding for other devices
- Inpection of 2.4 Ghz devices



C1, C2, C3, C5, C7
Need to be less then
1Ω X_c
$\frac{1}{2\cdot\pi\cdot f\cdot C} = 2\cdot\pi\cdot 27\cdot 10^6\cdot 10\cdot 10^{-6}$
$= 0.589\Omega$

RFC + R1 need to be more then 500Ω, RFC will stop R1 from parallel the 50Ω output
$500-251 = 249\Omega\ X_L$
RFC need to be at least $249\Omega\ X_L$
$X_L = 2\cdot\pi f L$
$RFC = 2\cdot\pi\cdot 27\cdot 10^6\cdot 1.7\cdot 10^{-6} \Rightarrow 288\Omega\ X_L$

R_1 R_2 will feed the EKA with 47.8 mA
$\Rightarrow 12/251 = 251\Omega$

That’s It!

- Our white-paper “27_Mhz_keyboard_insecurities.pdf”
- http://www.remote-exploit.org
- Yes, we are doing complete sets
- Price is not clear jet. Guess will end up somewhere around ~30-40 Euros