hardware hacking for software people

Dobrica Pavlinušić
http://blog.rot13.org/
FSEC 2013, Varaždin

http://bit.ly/fsec2013-hh

Open Hardware is game changer!

Open Hardware - documentation, schematic, gerbers, source available

If it’s not open hardware, open it and start hacking on it!

Overview

- **wireless 2.4GHz keyboards with nRF24L01**
- RTL-SDR as universal RF receiver
- IMS RF band: 315,433,868,915 MHz
- IR receiving, analysis and sending
- some microcontroller choices
  - Arduino - AVR, 5V, ARM 3.3V
  - Bus Pirate - PIC, 1.8-5V
  - r0ket, Maple Leaf - ARM Cortex M3, 3.3V
  - Raspberry Pi, ARM, 3.3V
  - CubieBoard, ARM A10/A20, 3.3V, more pins
- other useful supporting hardware
  - USB microscope, solder station...

Wireless keyboards

http://blog.rot13.org/2012/12/is-wireless-keyboard-safe-for-your-passwords.html

Three basic types of RF connectivity

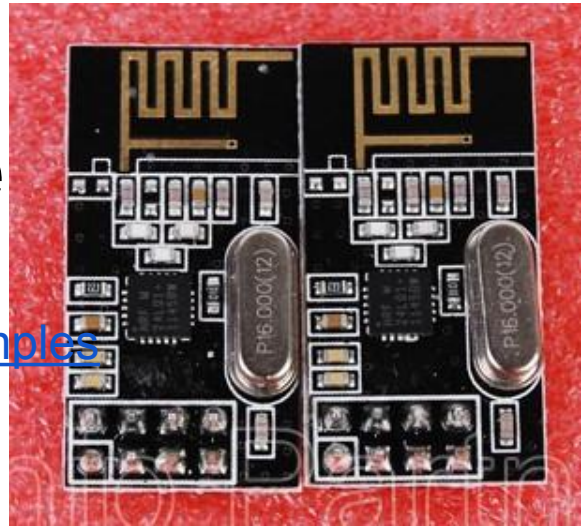
1. KeyKeriki v1.0 - 27 MHz
   http://www.remote-exploit.org/articles/keykeriki_v1_0_-_27mhz/index.html
2. KeyKeriki v2.0 – 2.4GHz - nRF24L01 - 1 or 2 Mbit/s
   http://www.remote-exploit.org/articles/keykeriki_v2_0__8211_2_4ghz/index.html
3. Ubertooth One - 2.4 GHz - Bluetooth
   http://greatscottgadgets.com/ubertoothone/

All somewhat complicated (KeyKeriki uses multiple radios), requires soldering or expensive kits

But seed of doubt is planted: are they secure?!

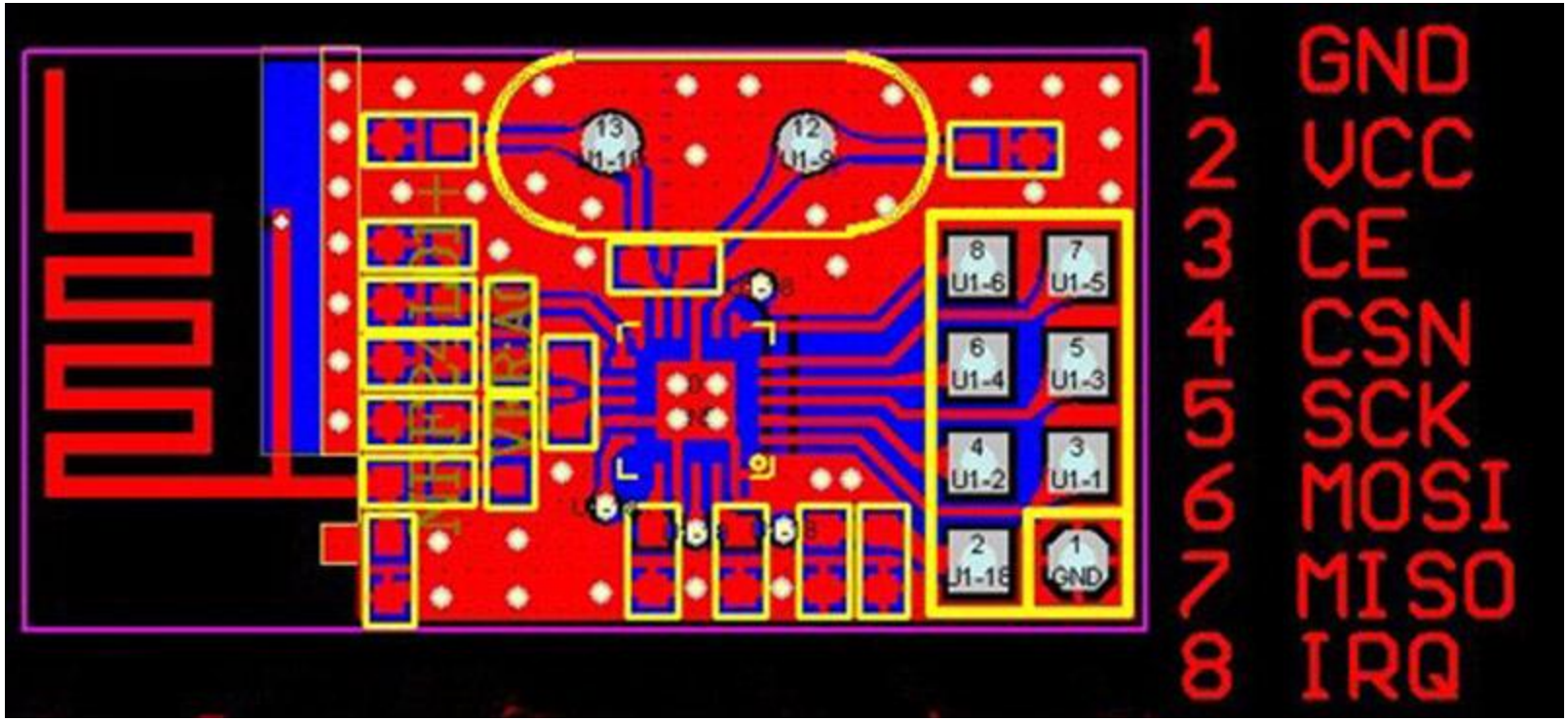
Most newer 2.4GHz (not bluetooth!) keyboards (with dongle) use nRF24L01

nRF24L01 - cheap module



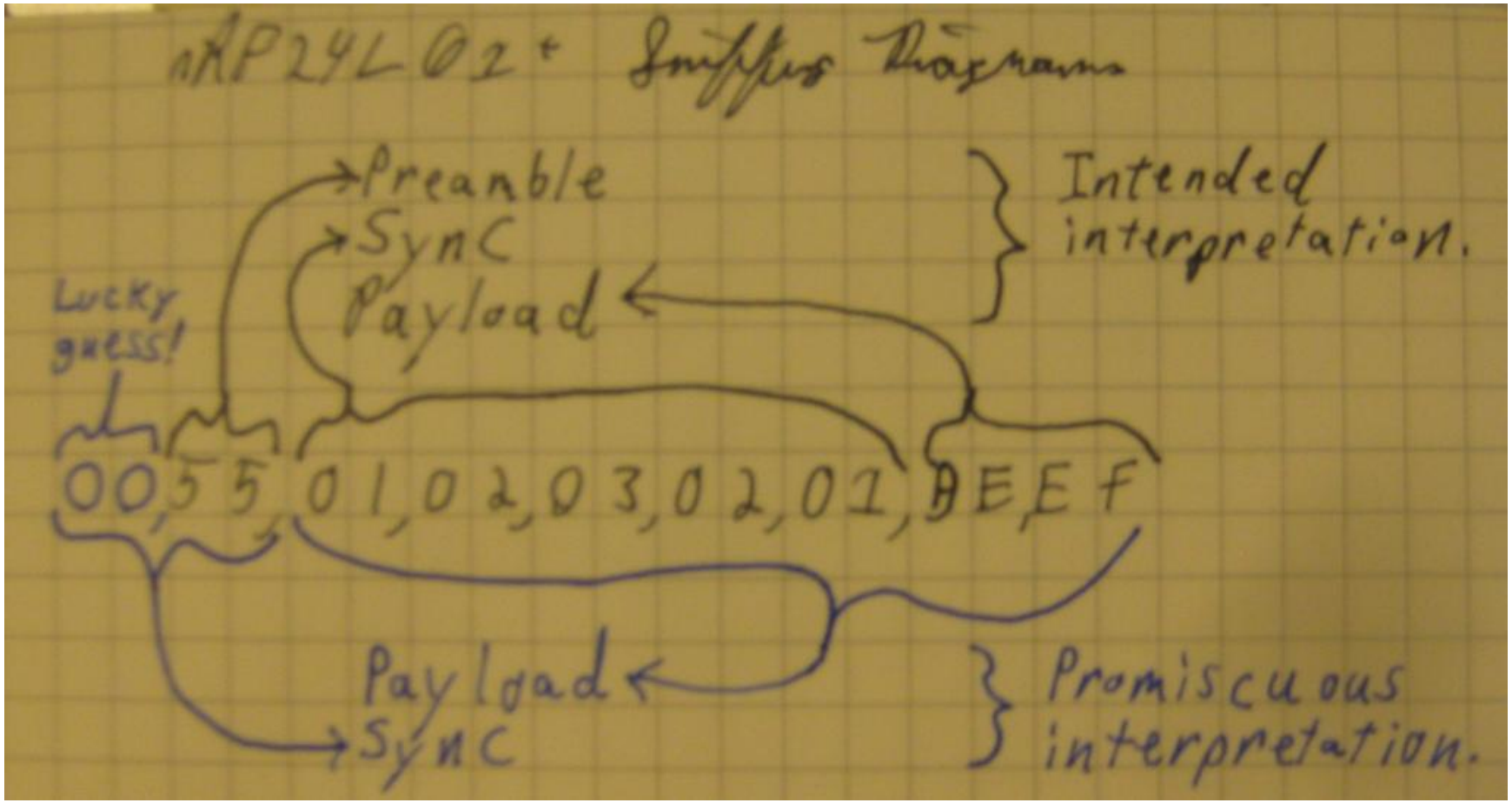
http://arduino-info.wikispaces.com/nRF24L01-Mirf-Examples

http://www.ebay.com/itm/251044600998 - buy in pair!



Can we sniff with nRF24L01?

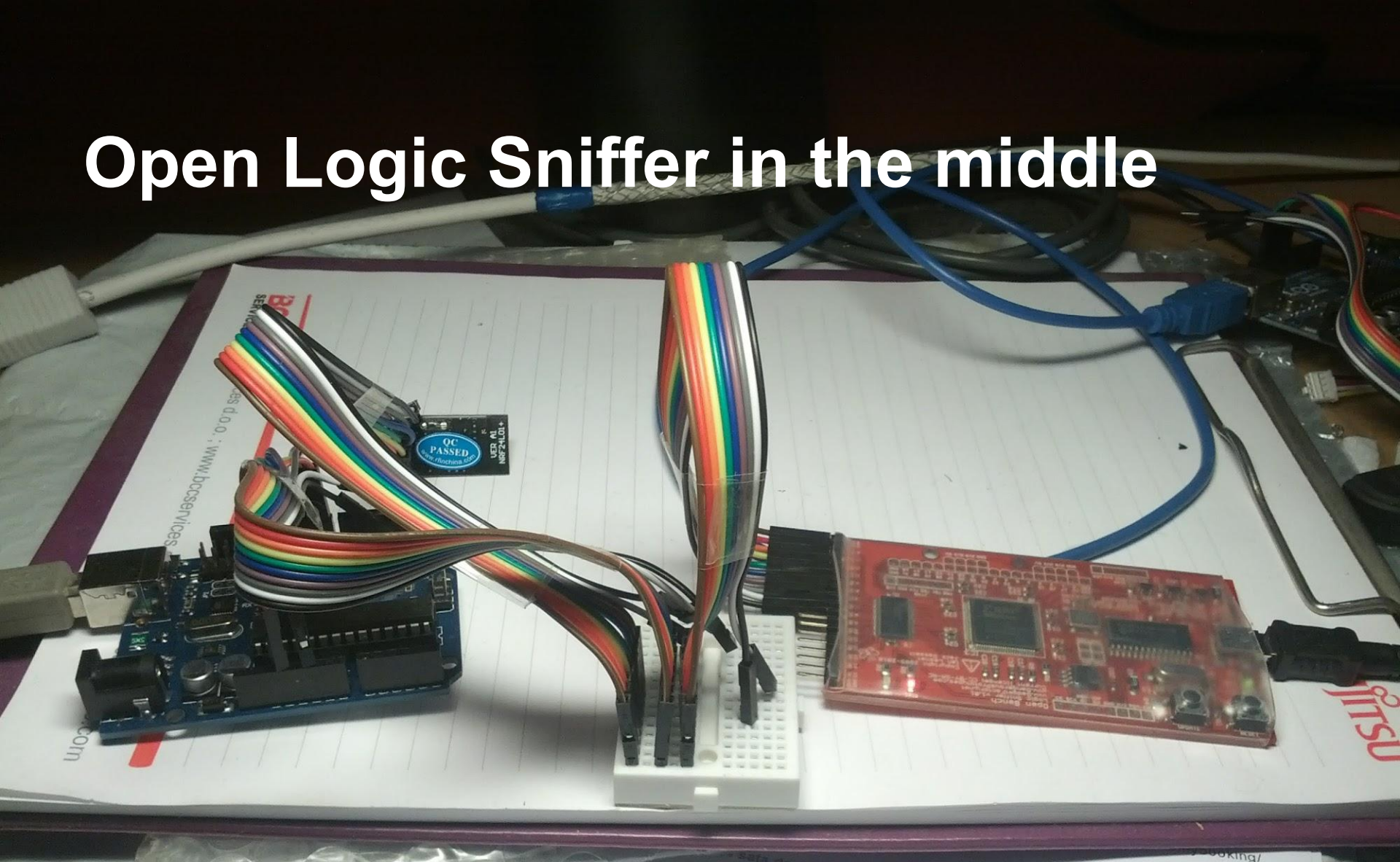
http://travisgoodspeed.blogspot.com/2011/02/promiscuity-is-nrf24l01s-duty.html



Arduino ping-pong

https://plus.google.com/u/0/115404771036822212816/posts/efMJQPTi2su

Open Logic Sniffer in the middle



http://github.com/jawi/ols.git ols-0.9.7-RC1 self-compiled on Debian sid amd64 (Java librxtx is pain otherwise!)
http://saturn.ffzg.hr/rot13/index.cgi?open_logic_sniffer

nrf24L01_plus

Dobrica Pavlinušić Shared publicly Jul 20, 2013

I'm looking for #nRF24L01 #Arduino library for which I can specify number of bytes in address (so, no #define please!) Should I write another one?!
Damjan Georgievski Jul 20, 2013

Doesn't look as a big patch to make the address length an extra argument https://github.com/kehribar/nrf24L01_plus/blob/master/nrf24.c#L69

Dobrica Pavlinušić Jul 21, 2013

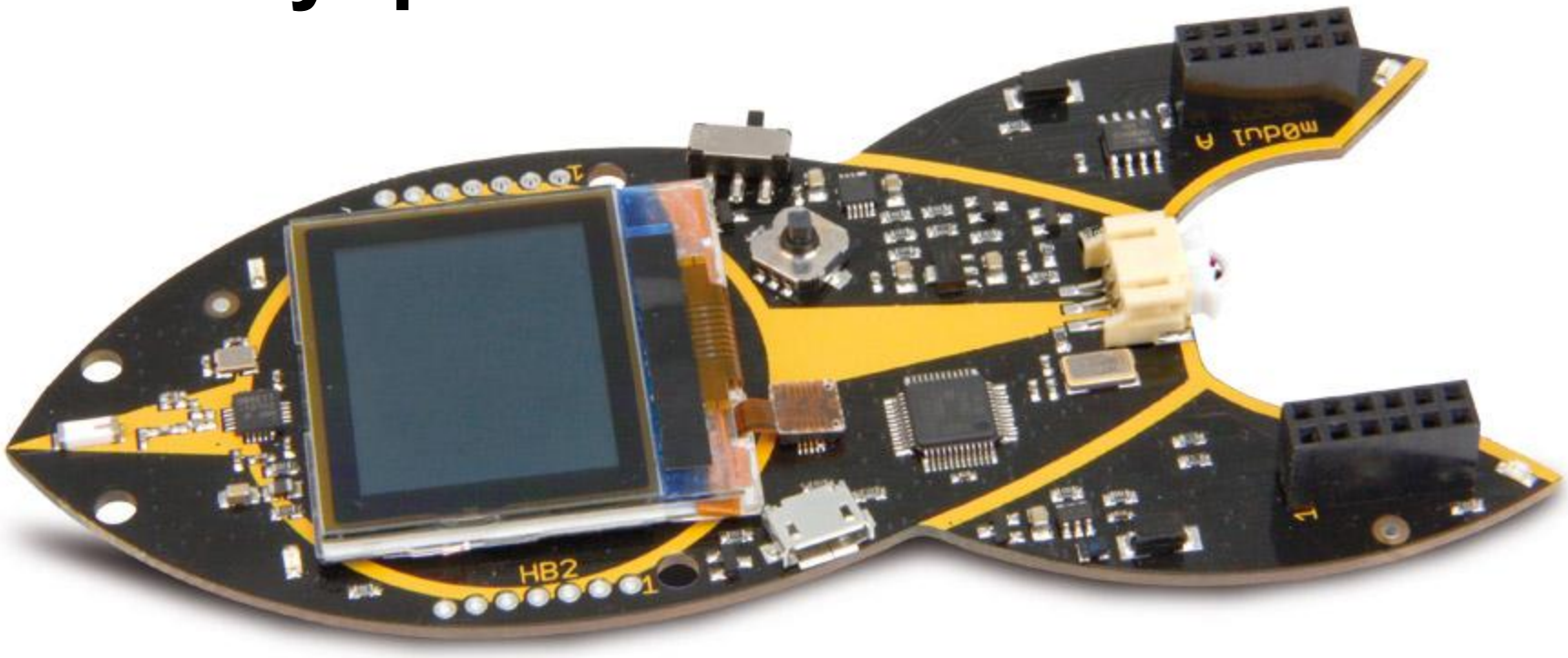
True, but I also need much more low-level access because I'm porting http://travisgoodspeed.blogspot.com/2011/02/promiscuity-is-nrf24l01s-duty.html (and have no use for most of this library).

If I'm not mistaken I saw R0ket in Kika, so you might try http://sarwiki.informatik.hu-berlin.de/R0ket_Keyboard_sniffer and let me know if it works because I'm basing my port on that code as opposed to combination of C and python which Travis did.

Dobrica Pavlinušić Jul 22, 2013

+Damjan Georgievski I read through source code of ntf24L01_plus and it really is nicest library I've seen so far. It's not Arduino API based, so I'm somewhat reluctant to base my solution on it (since part of the goal is to show how Arduino based code can be run on different platforms since I think that Arduino API is new standard for embedded development -- blog post about it is pending :-)

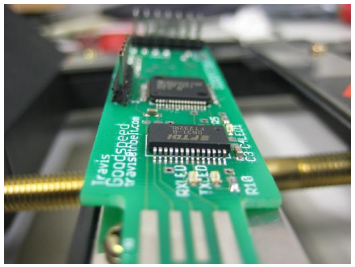
First try: port r0ket sniffer to Arduino



- http://www.pollin.de/shop/dt/ODE4OTgxOTk-/Bausaetze_Module/Module/Microcontroller_Experimentierplatine_r0ket.html
- http://sarwiki.informatik.hu-berlin.de/R0ket_Keyboard_sniffer
- First encounter with porting Arduino SPI API
- **Utter failure. I can't sniff a thing!**
- Code does work (somewhat) - there is hope in porting code from one architecture (ARM Cortex M3) to another (AVR)!

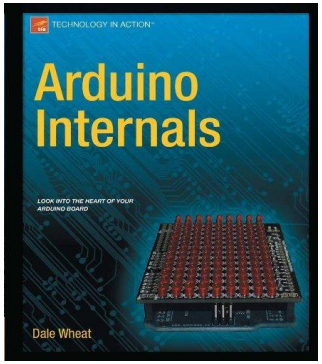
Travis Goodspeed - GoodFET

http://goodfet.sourceforge.net/

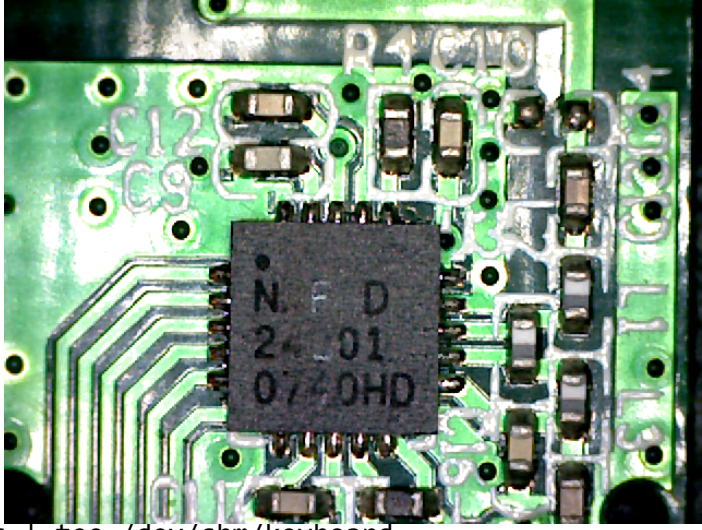


http://goodfet.sourceforge.net/clients/goodfetnrf/

- MSP430 based, have to solder it!
- How about port to Arduino Uno?
- It does support few AVR boards...
- Arduino Internals by Dale Wheat
- ...read, read,hack, google, hack…
- port to different AVR! (CPU freq)
- luckily nRF24L01 is 5V tolerant!
- http://git.rot13.org/?p=goodfet;a=shortlog;h=refs/heads/Arduino_Uno



Chicony KG-0609



http://saturn.ffzg.hr/rot13/index.cgi?chicony_kg_0609

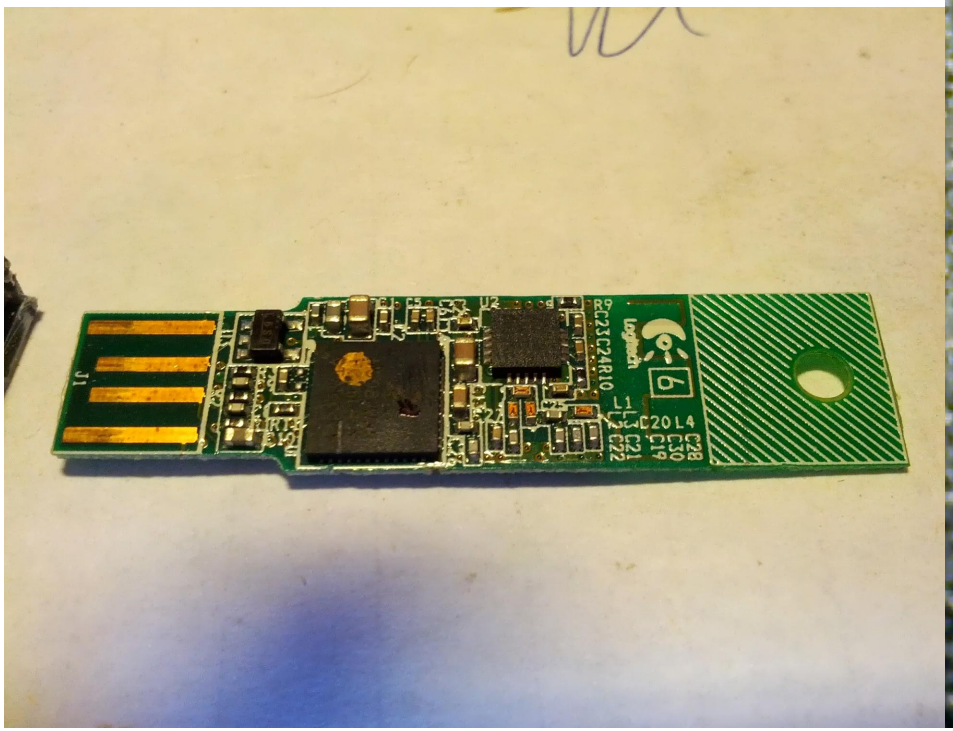
http://git.rot13.org/?p=goodfet;a=shortlog;h=refs/heads/Arduino_Uno

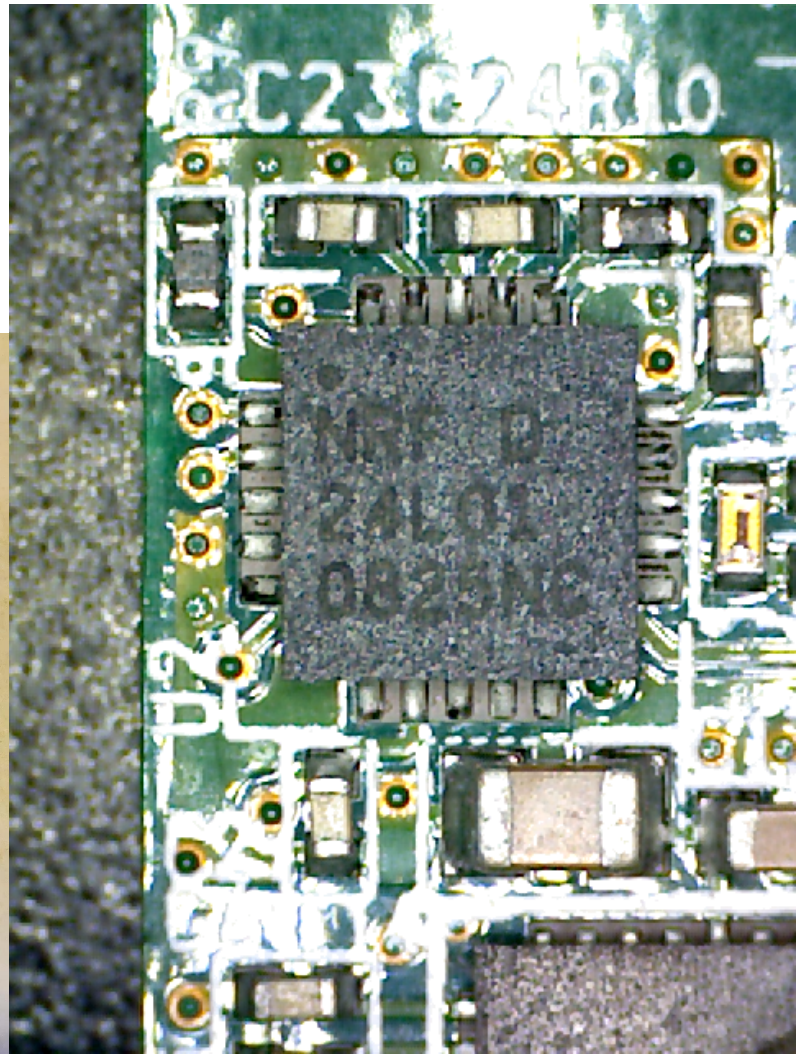
```
dpavlin@blue:/blue-zfs/MSP430/goodfet/client$ ./goodfet.nrf sniffmacs | tee /dev/shm/keyboard
Holding autotune on 2402 MHz
sync,mac,r5,r6
'aa,bffffdea01,02,0f' looks valid       1       0.00094
'aa,bffffdea01,02,0f' looks valid       2       0.00187
'aa,bffffdea01,02,0f' looks valid       3       0.00143
'55,5ffffef500,02,0f' looks valid       1       0.00047
'55,5ffffef500,02,0f' looks valid       2       0.00084
'aa,bffffdea01,02,0f' looks valid       4       0.00154
'aa,bffffdea01,02,0f' looks valid       5       0.00182
'aa,bffffdea01,02,0f' looks valid       6       0.00202
'55,5ffffef500,02,0f' looks valid       3       0.00094

dpavlin@x200:/rest/cvs/goodfet/client$ ./goodfet.nrf tune aa,bffffdea01,02,0f

dpavlin@blue:/blue-zfs/MSP430/goodfet/client$ ./goodfet.nrf sniff
Listening as bffffdea01 on 2402 MHz
 cc af f7 bf ff 1f e0 19 54 3b 9f 2d 2d c4 d4 1d 6a 96 d5 16 93 2a 95 b6 2b 74 d4 aa 85 72 91 41
 cc ef f7 bc fe 7f e0 19 46 c2 5e b0 c2 5a 54 a5 48 cd 42 2c d8 99 dd 19 7a aa a5 85 4a 84 55 15
 cc 2f f7 bd 42 5f e0 19 4c bf be dc d5 69 ab 19 55 8e 95 4f 8f 66 ed ac a7 d2 b6 8d d1 1b 8b 2a
 cc 6f f7 a2 62 ff e0 19 58 26 9e 32 25 20 82 0b 56 d5 12 54 3a a6 bd 5f 7d 75 ed fd 14 b2 4b 48
 cc af f7 a2 7f 9f e0 19 5b 61 5d bf 1a 62 50 b6 a9 14 b8 d9 d2 1a 52 11 0a 25 4d aa a8 dc 85 1a
 cc ef f7 bf 1d 9f e0 19 53 1f 14 a5 14 54 c3 a2 14 d1 84 59 25 56 09 08 77 55 4a 22 ce ad 56 91
```

https://twitter.com/dpavlin/status/366151267548020737

Logitech - possible?

I guess so! Anybody want to try it out?





buy nRFL01

2pcs NRF24L01+ 2.4GHz Antenna Wireless Transceiver Module For Microcontr

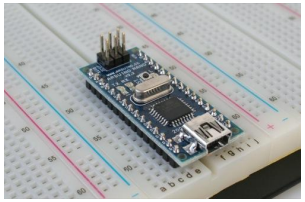
http://www.ebay.com/itm/2pcs-NRF24L01-2-4GHz-Antenna-Wireless-Transceiver-Module-Microcontr-/251044600998?pt=LH_DefaultDomain_0&hash=item3a736c9ca6

You will need two of them!

http://dx.com/p/upgraded-2-4ghz-nrf24l01-wireless-transceiver-module-for-arduino-black-147596

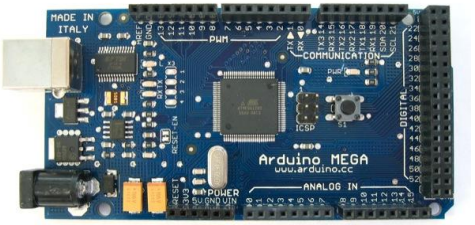
http://dx.com/p/2-4ghz-wireless-nrf24l01-module-150867

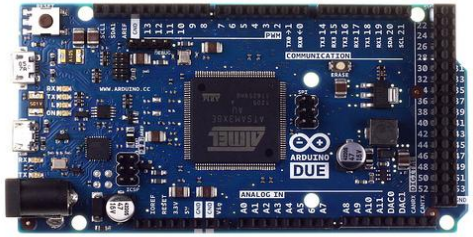
Arduino - API first!



http://blog.rot13.org/2013/07/is-arduino-api-new-standard-for-embedded-development.html

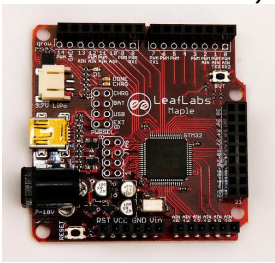
- Arduino Uno - ATmega328
- Arduino Nano - ATmega328 - breadboard friendly
- Arduino Leonardo - ATmega32u4 - USB hacks!
- Arduino Mega - ATmega2560 - bigger, more IO
- Arduino Due - Atmel SAM3X8E ARM Cortex-M3
- Pinguino - PIC18 8-bit or PIC32 32-bit CPUs
- The Maple - STM32F103RB 72MHz ARM Cortex M3
- Energia - MSP430 16MHz board for under $10
- pcDuino - A10 1GHz ARM Cortex A8
- Papilio FPGA - Spartan 3 or 6 FPGA - AVR8 or ZPUino

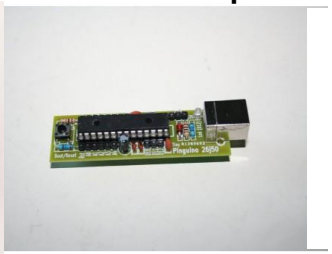


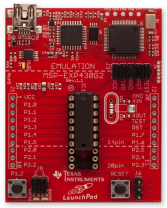


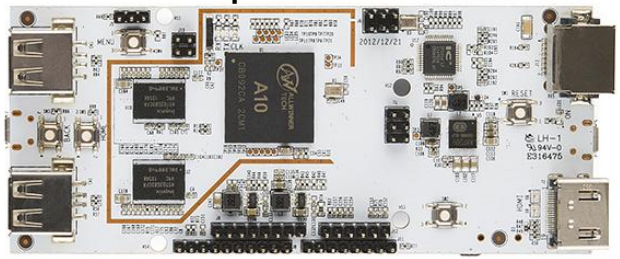
Many more different boards with (some) API compatibility

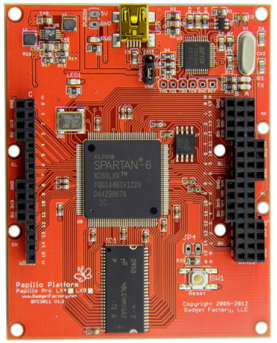
5V vs 3.3V, some compatible with Arduino shield pinout









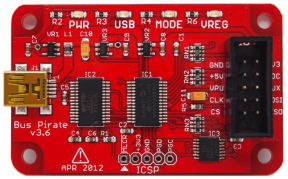


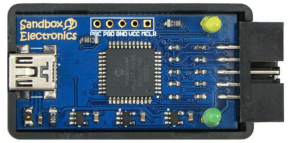
buy Arduino parts

http://blog.rot13.org/2013/08/monitoring-room-temperature-using-arduino.html

- Solderless Breadboard with 400 Tie-Point
- Breadboard Jumper Wires
- Breadboard Jumper Wire Set
- DHT11 1-Wire Single Pin Thermometer/Hygrometer Module
- DS18B20 Programmable Resolution 1-Wire Digital Thermometer
- Arduino Compatible 1.6" Nokia 5110 LCD Module with Blue Backlit

nRF24L01 + Bus Pirate





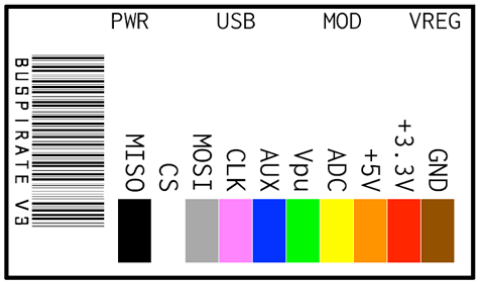
http://www.seeedstudio.com/depot/bus-pirate-v36-universal-serial-interface-p-609.html

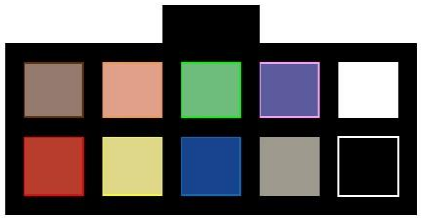
http://sandboxelectronics.com/store/index.php?main_page=product_info&cPath=65&products_id=185

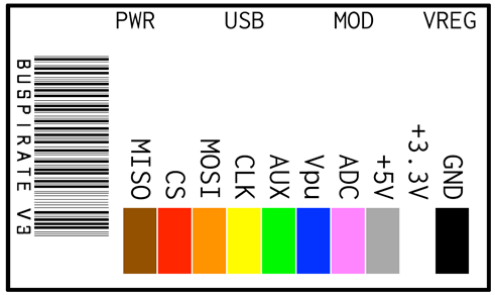
http://www.seeedstudio.com/depot/bus-pirate-cable-p-932.html

- Bus Pirate v3.6 universal serial interface http://dangerousprototypes.com/docs/Bus_Pirate
- different voltages (1.8V-5V from MCU power, sense) and protocols
  - UART, SPI, JTAG, I2C, SUMP logic analyzer (4K samples, <~1Mhz)
- scripting mode to drive nRF24L01 from python script
  - https://github.com/dpavlin/nRF24L01-buspirate
  - my fork, reviewed by someone who knows python, hi Aka :-)
- differnet modes have differnet pinout, take care when connecting!

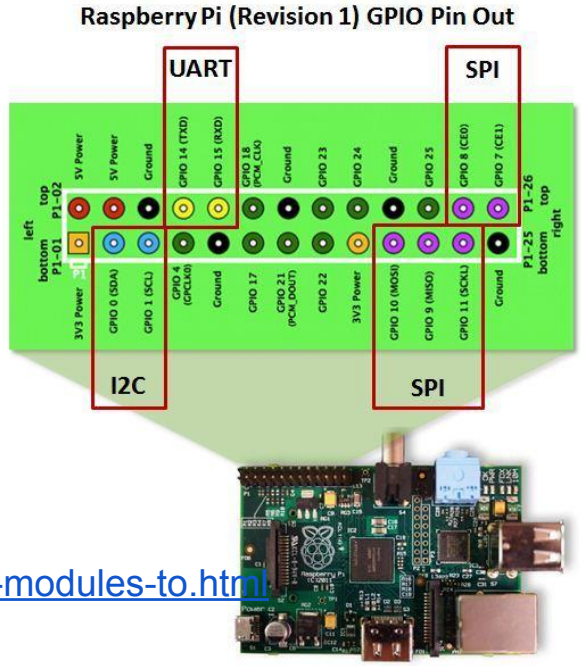
http://dangerousprototypes.com/docs/Common_Bus_Pirate_cable_pinouts







nRF24L01 + Raspberry Pi



nRF24L01 RF Transceiver

https://github.com/kehribar/nrf24L01_plus

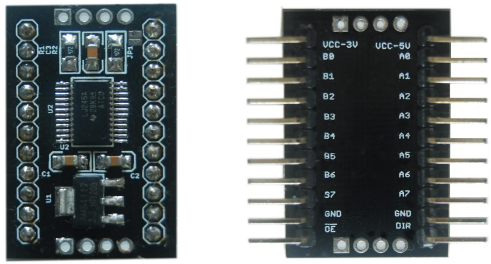
http://www.raspberrypi.org/phpBB3/viewtopic.php?f=45&t=17061

http://arduino-for-beginners.blogspot.fr/2013/02/setup-nordic-nrf24l01-rf-modules-to.html

setup it as hub for your devices

Raspberry Pi is 3.3V device so don't blindingly connect 5V Arduino sensors to it!

Level shifter comes to rescue:
http://www.ebay.com/itm/121032259497



there are models with less pins too!

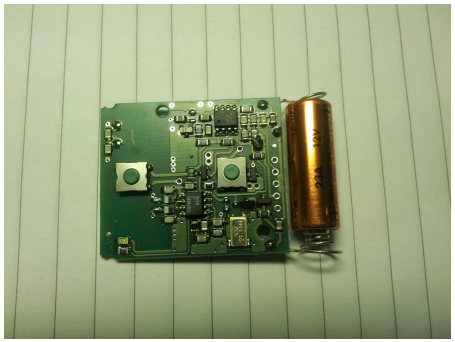
RTL-SDR - NSND Osijek 2013

http://blog.rot13.org/2013/02/nsnd-2013-osijek-rtl-sdr-software-defined-radio.html

SDR receiver 8-bit, 2.4 MS/s, 24-1766 MHz

http://sdr.osmocom.org/trac/wiki/rtl-sdr

- good for IMS bands (433, 868 Mhz EU) or ADS-B (1090 Mhz) - with home-made antennas! All antennas are not equal!
- weather sensors, blinds, garage doors



What about sending IMS RF?

https://code.google.com/p/rfcat/

CC1111 (RF+MCU) vs CC1101 (RF only)

443 or 868 or 915 MHz - select **one**

Notice pin spacing! (2mm vs 2.54 mm)

Chronos AP dongle now in with MSP430F5509 and CC1101 so rfcat don't work anymore!

http://saturn.ffzg.hr/arh/index.cgi?msp430_chronos

Cheaper alternative for Arduino

- 315 or 434 MHz only, AM modulation
- buy pair - easier to debug and play with!
- http://www.ebay.com/itm/251044600998
- Separate sender and receiver module

USB IR Toy - easy IR hacking

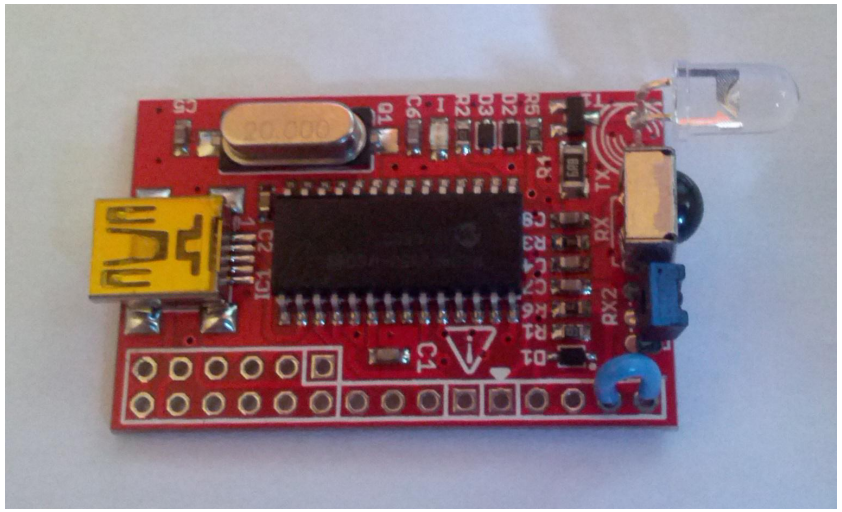
http://blog.rot13.org/2013/04/usb-ir-toy---pic-18f2550-fw-update-under-linux.html

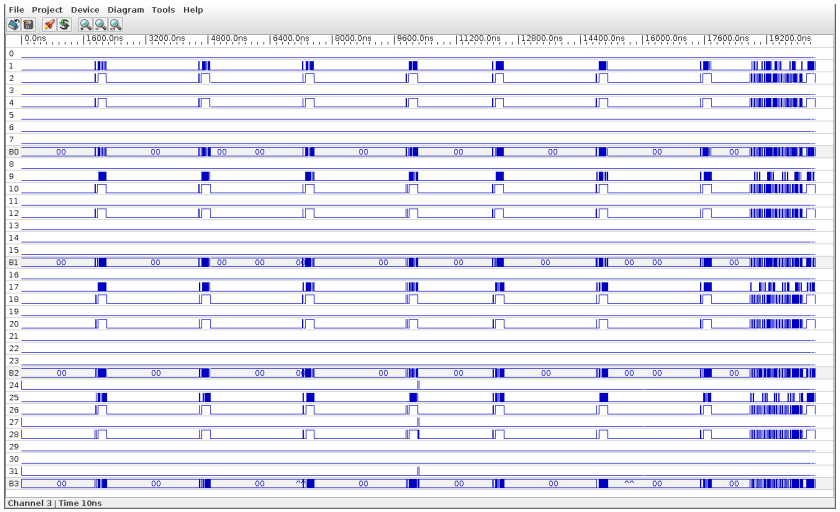
http://dangerousprototypes.com/docs/USB_Infrared_Toy

You will need to upgrade PIC firmware first!

Can be used as SUMP IR analyzer

Record and playback IR codes with ease!



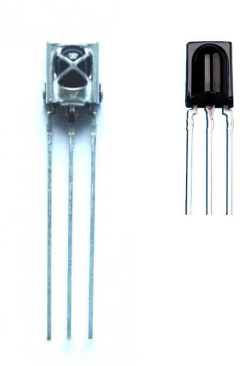


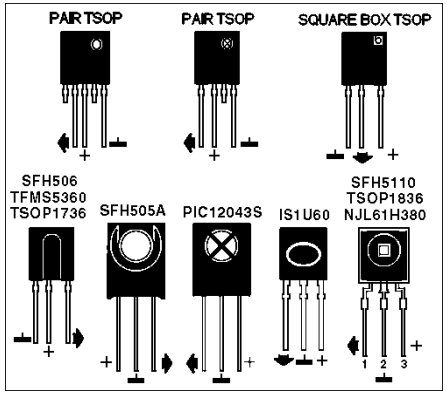
IR Arduino alternative

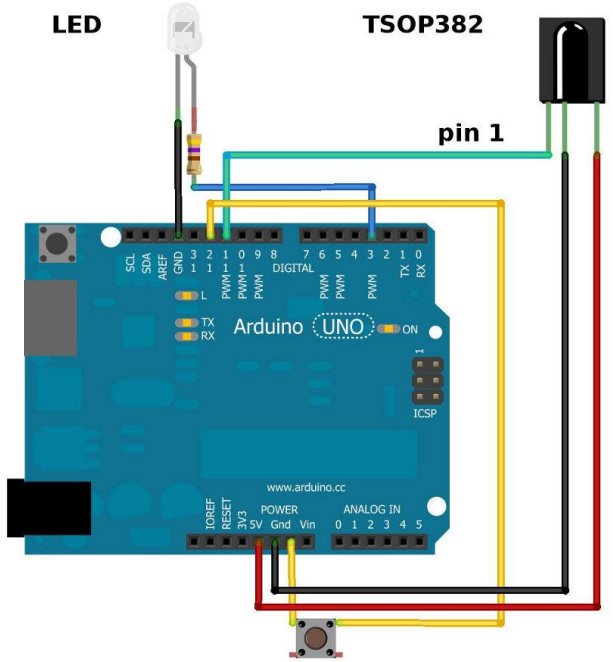
Requires more software tweaking than IR Toy

http://www.righto.com/2009/08/multi-protocol-infrared-remote-library.html

- 5 pairs Infrared Diode LED IR Emission & Receiver http://www.ebay.com/itm/281010446403
- you **will need additional resistor for IR led!**

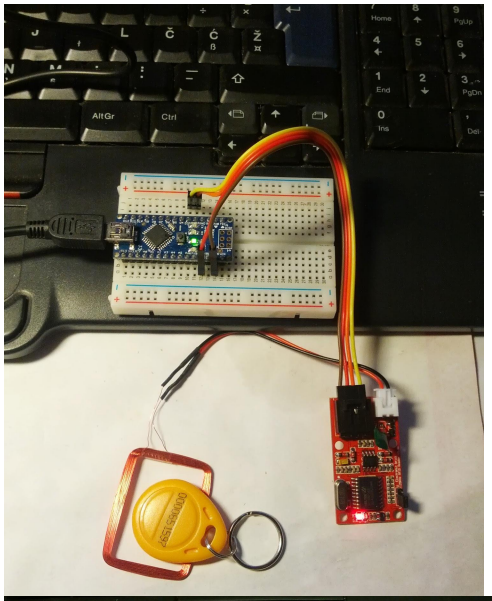


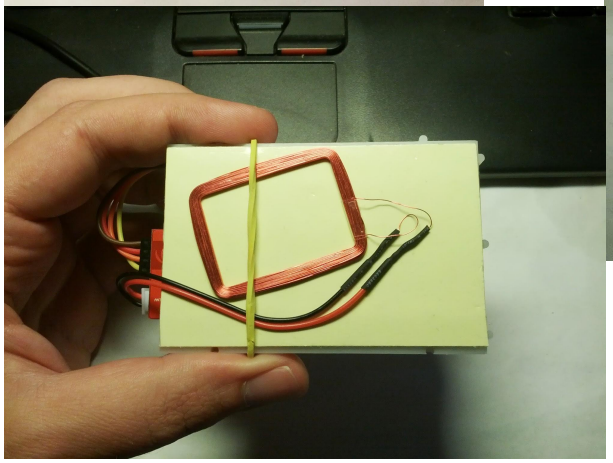


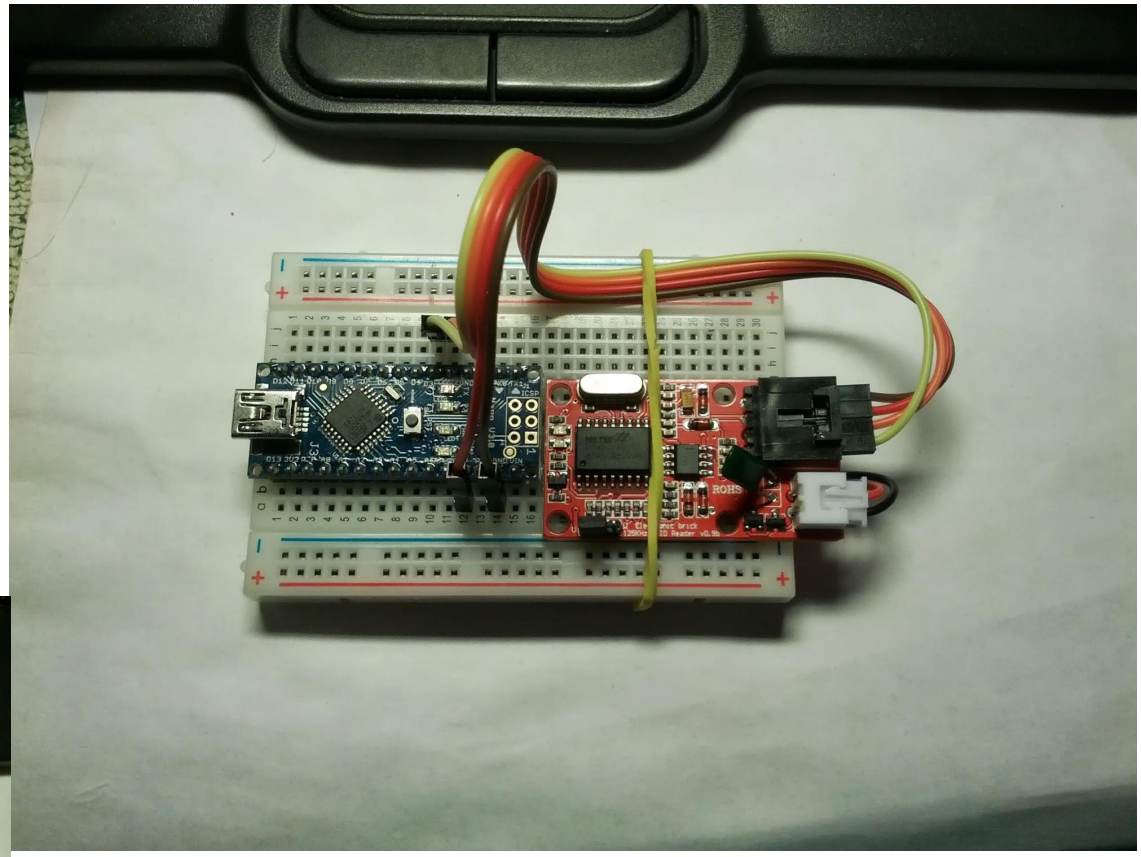


Arduino Nano + 125KHz RFID

http://www.seeedstudio.com/wiki/index.php?title=Electronic_brick_-_125Khz_RFID_Card_Reader
https://plus.google.com/115404771036822212816/posts/VPnpbJqn2xo







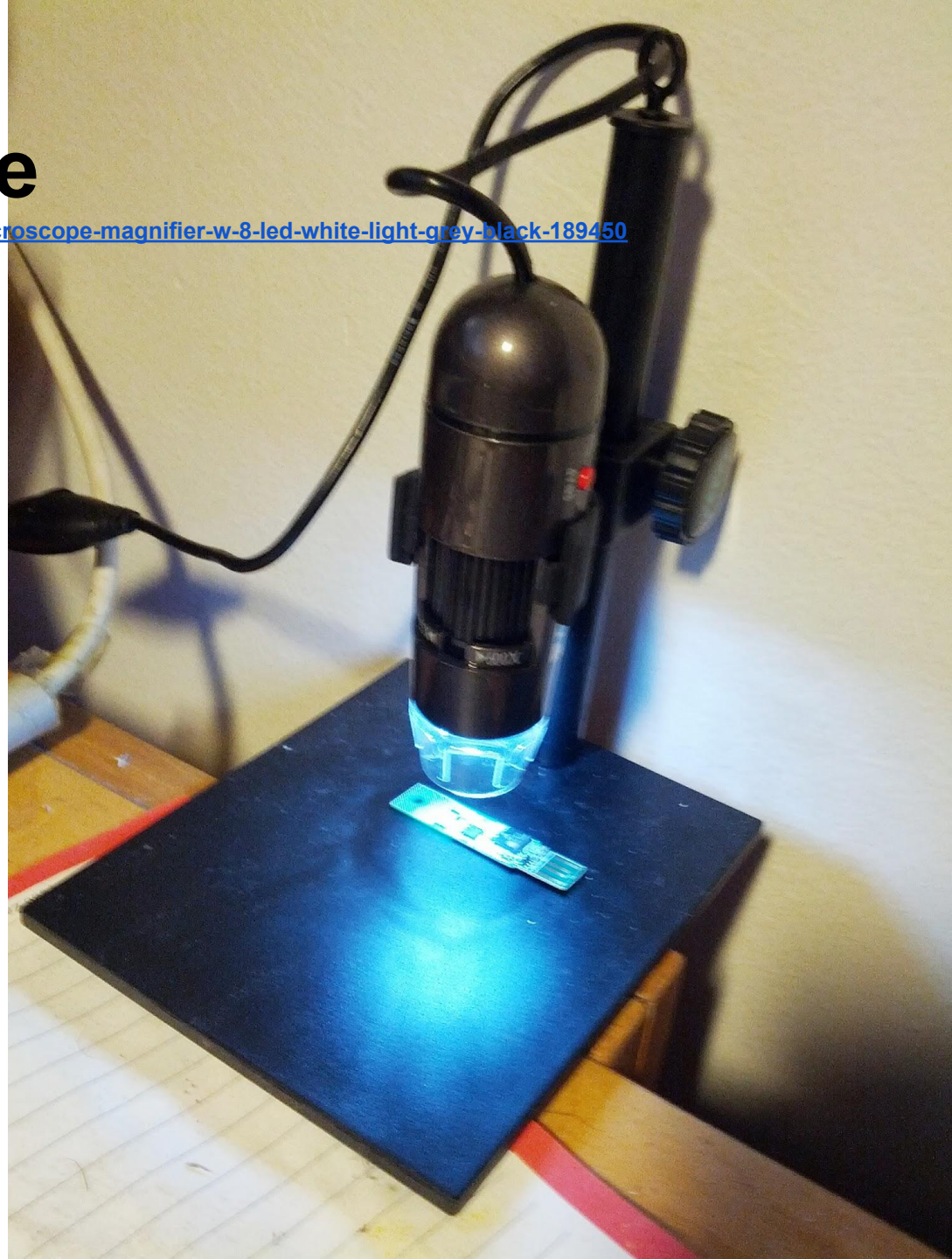
It was cheap sell-out component (5V serial)

USB Microscope

http://dx.com/p/s04-25-600x-usb-digital-photography-microscope-magnifier-w-8-led-white-light-grey-black-189450

Good for inspection

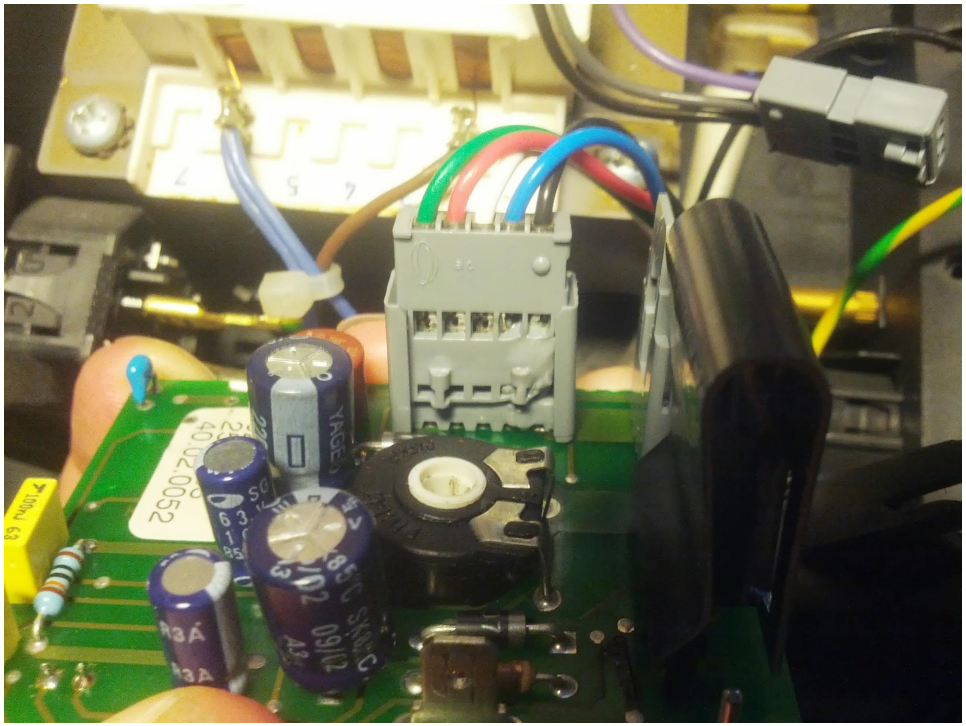
640*480 - don’t believe megapixels, has noticeable lag, zoom too high, this is only usable distance!

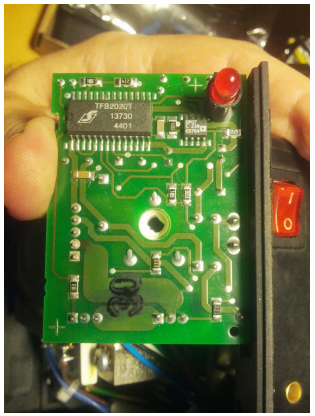


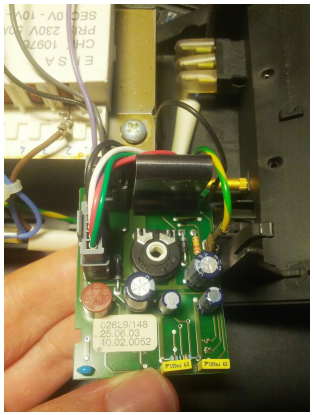
ERSA analogue soldering station, 80W

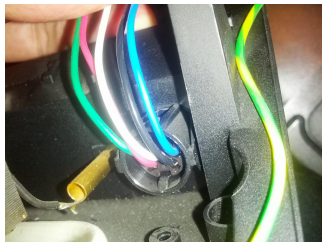
570 Kn, Nuškalo, temperature regulation

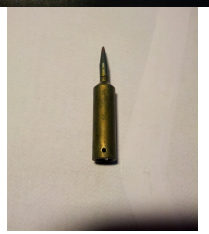
fail > 500°C, burned tip!











Bitcoins in Mojo FPGA

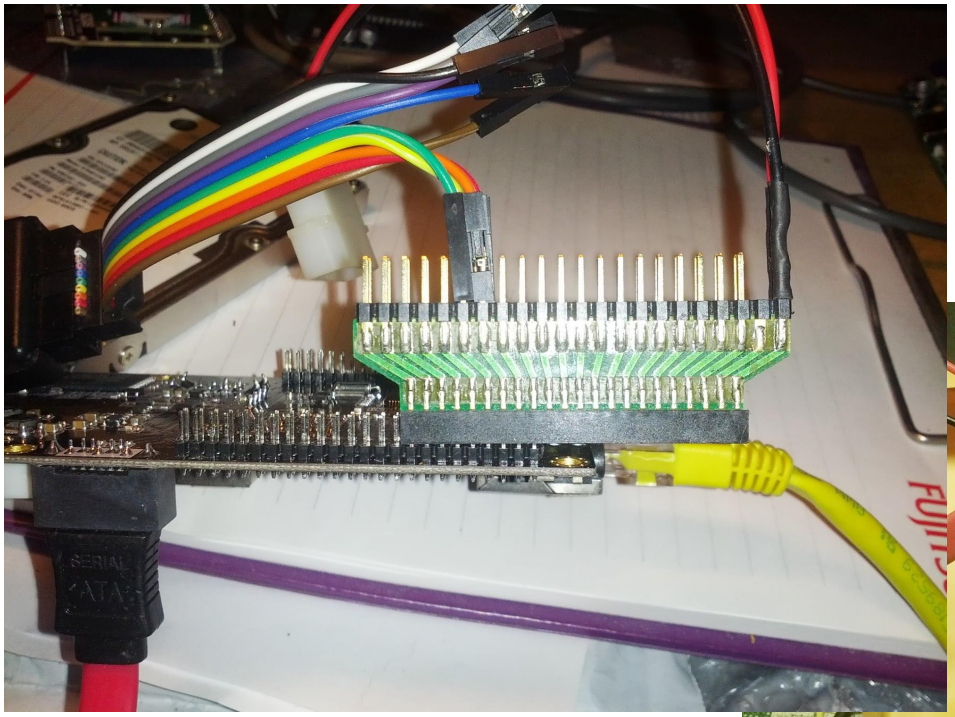
Mining #bitcoins at rate of 35.79 MH/s using +Embedded Micro mojo #fpga board. It's slower than GPU, but fun to watch.

https://plus.google.com/115404771036822212816/posts/4sTk4DEHncH

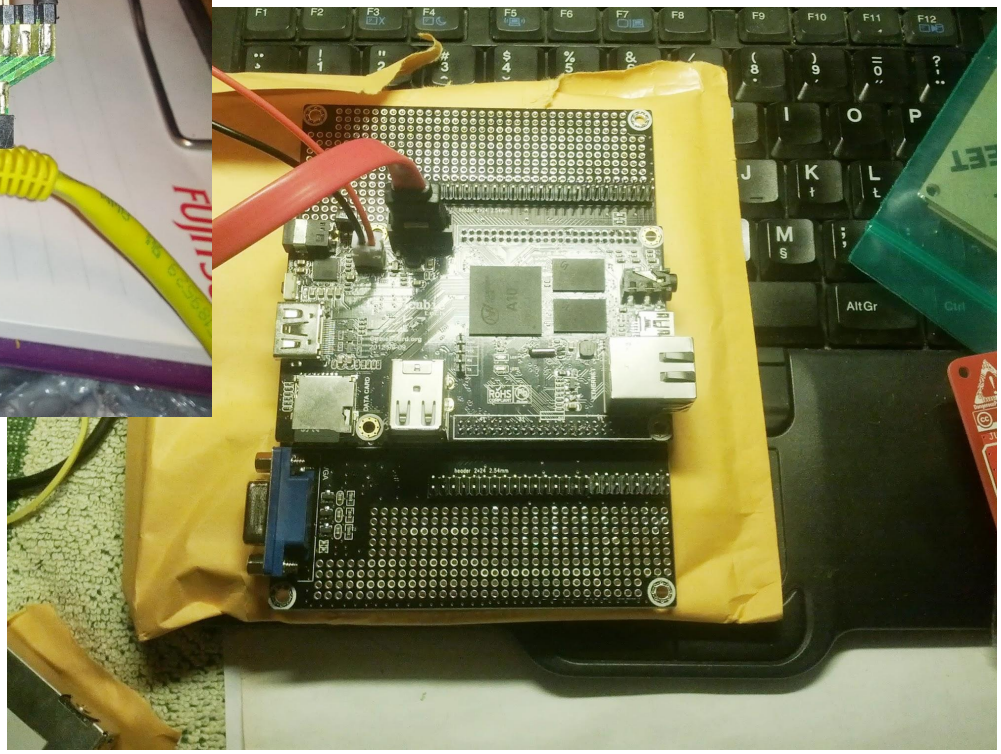
http://saturn.ffzg.hr/rot13/index.cgi?mojo

CubieBoard

https://plus.google.com/115404771036822212816/posts/VPnpbJqn2xo



2mm pins!



Seeking! Questions?

- Advice on board design (KiCAD? Fritzing?)
- Infrared microwave to convert into reflow owen http://youtu.be/NCGzKDTFBSQ (and somebody who wants to have it at home :-)
- everything else I don't have and don't know that I need, please donate! I'm starting to learn soldering :-)
- buy me something from my whishlist at ebay
- always buy more than one component (and pass rest of them to friends)

hardware hacking for software people

Dobrica Pavlinušić
http://blog.rot13.org/
FSEC 2013, Varaždin

http://bit.ly/fsec2013-hh