

# fx2adc: Using USB oscilloscopes as general purpose ADC

---

Steve Markgraf <[steve@steve-m.de](mailto:steve@steve-m.de)>

# Motivation

---

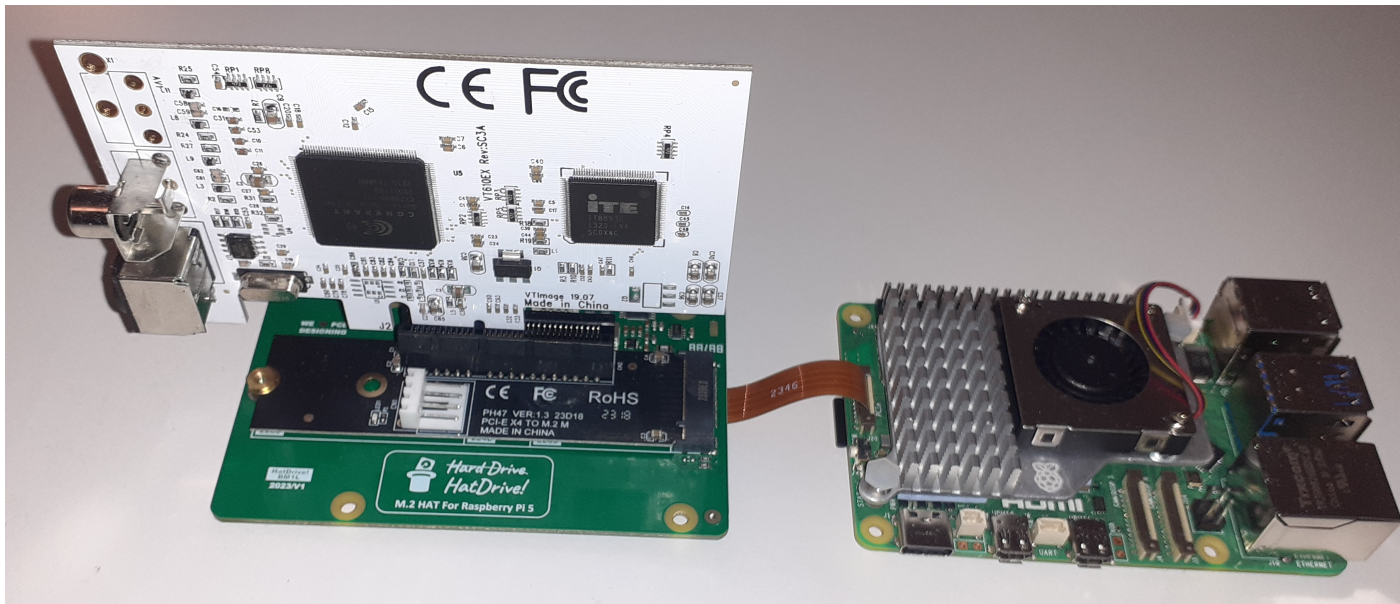
- Wanted to use vhsdecode (software defined VHS decoder)



<https://github.com/oyvindln/vhs-decode>

# Typical vhshdecode hardware

- Common hardware used are two clock-synchronized *cxadc* cards
- Video capture cards based on CX2388x that can be used as general purpose ADC
  - need PCI/PCIe-port
- 2x 40 MSPS @ 8 bit (FM audio, Video signal)



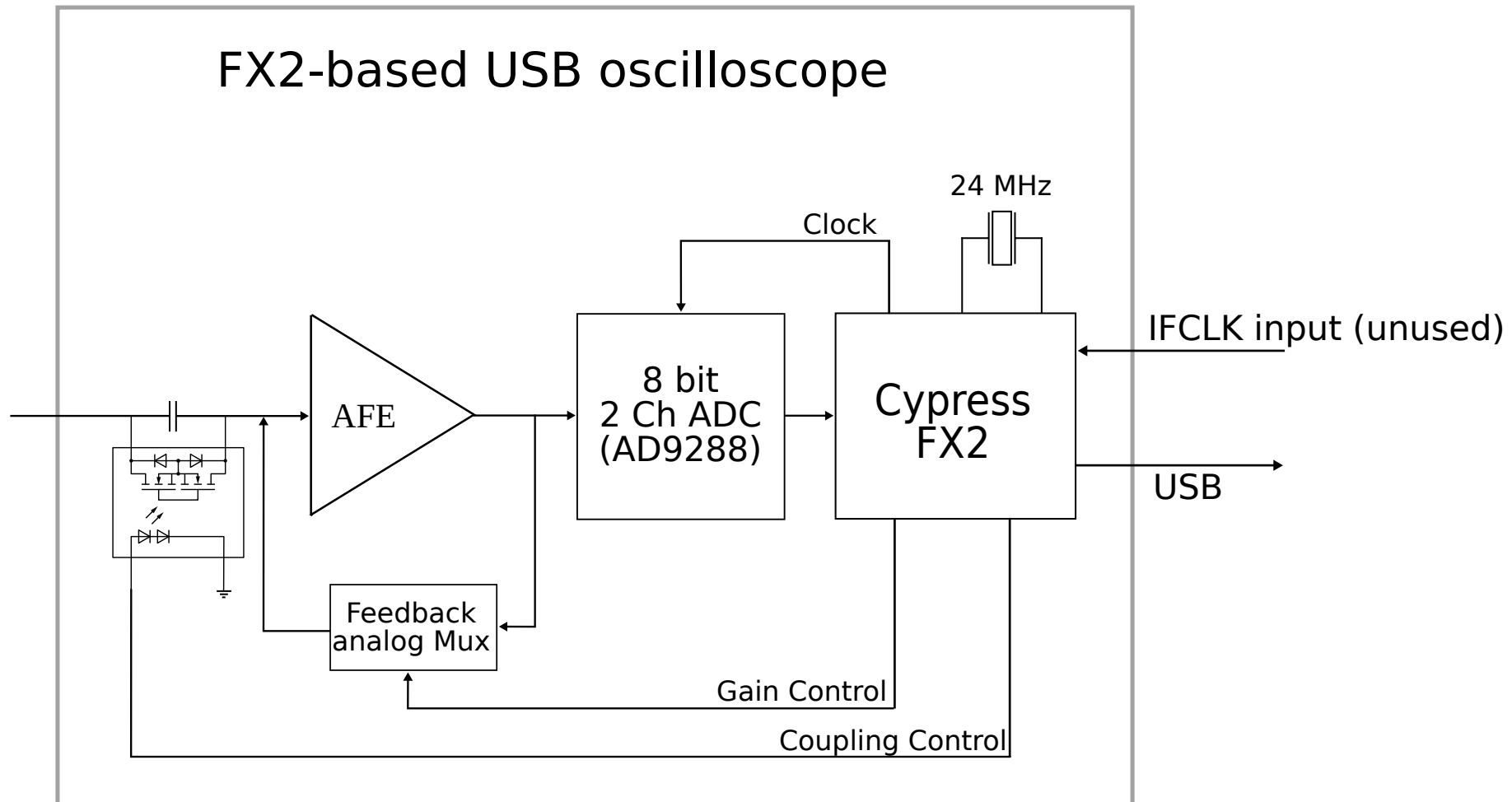
- Mine hadn't arrived yet...

# Hantek PSO2020

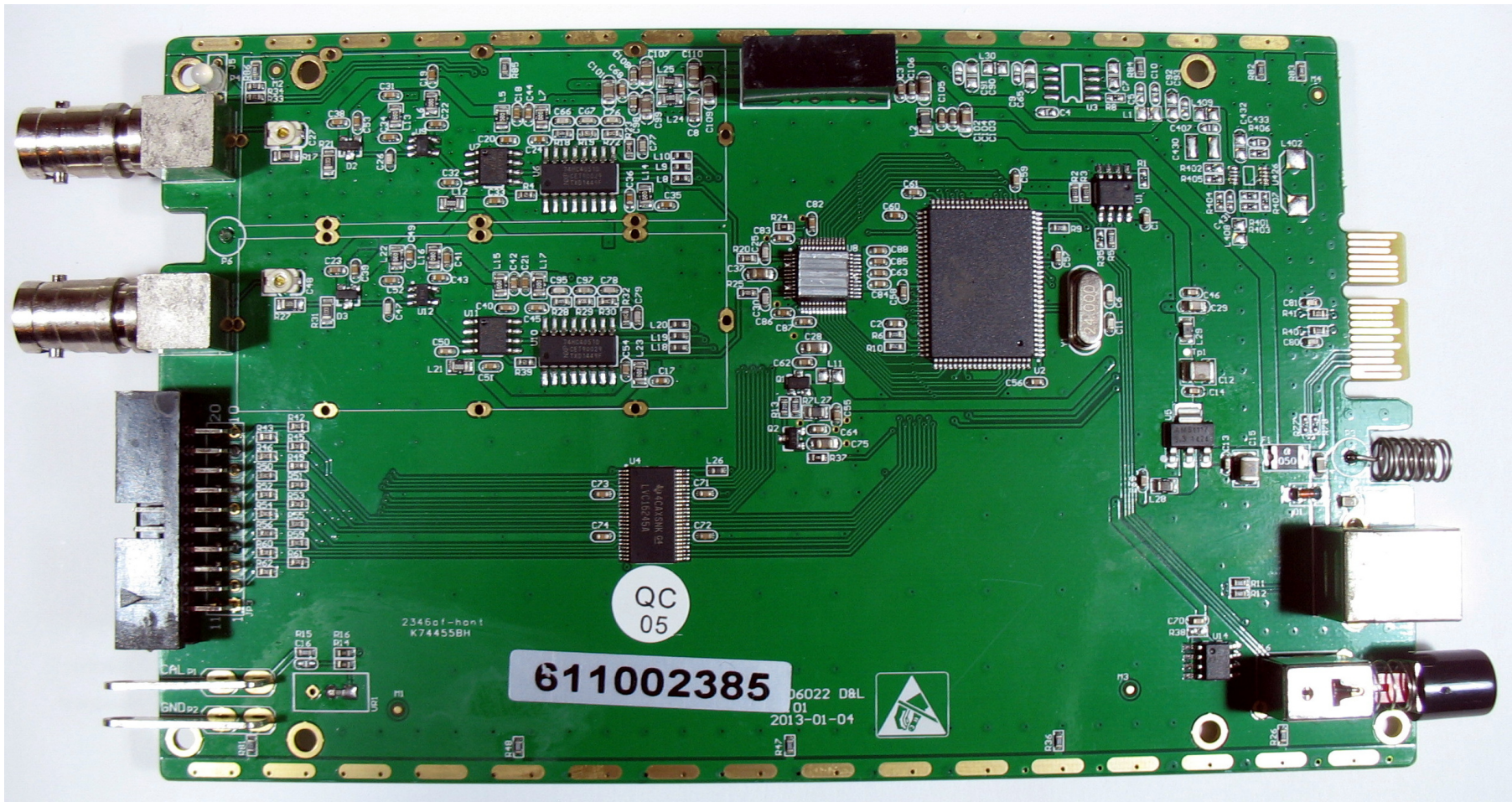
---



# FX2 oscilloscope block diagram



# FX2 oscilloscope PCB



Source: [https://sigrok.org/wiki/File:Hantek\\_6022bl\\_pcb\\_top.jpg](https://sigrok.org/wiki/File:Hantek_6022bl_pcb_top.jpg)

# USB oscilloscopes

---

Supported oscilloscopes:

- Hantek 6022BE
- Hantek 6022BL
- Hantek PSO2020
- Instrustar ISDS205A
- SainSmart DDS120
- YiXingDianZi MDSO
- LHT00SU1

# FX2 GPIF

---

ADC is connected via GPIF (General Purpose Interface):

- two 8 bit ports can be either used as 8 or 16 bit port
- limitation for 2 channel scopes
- either stream CH1 or CH1 + CH2
- CH2 alone with full sample rate not possible!



# FX2 GPIF clock modes

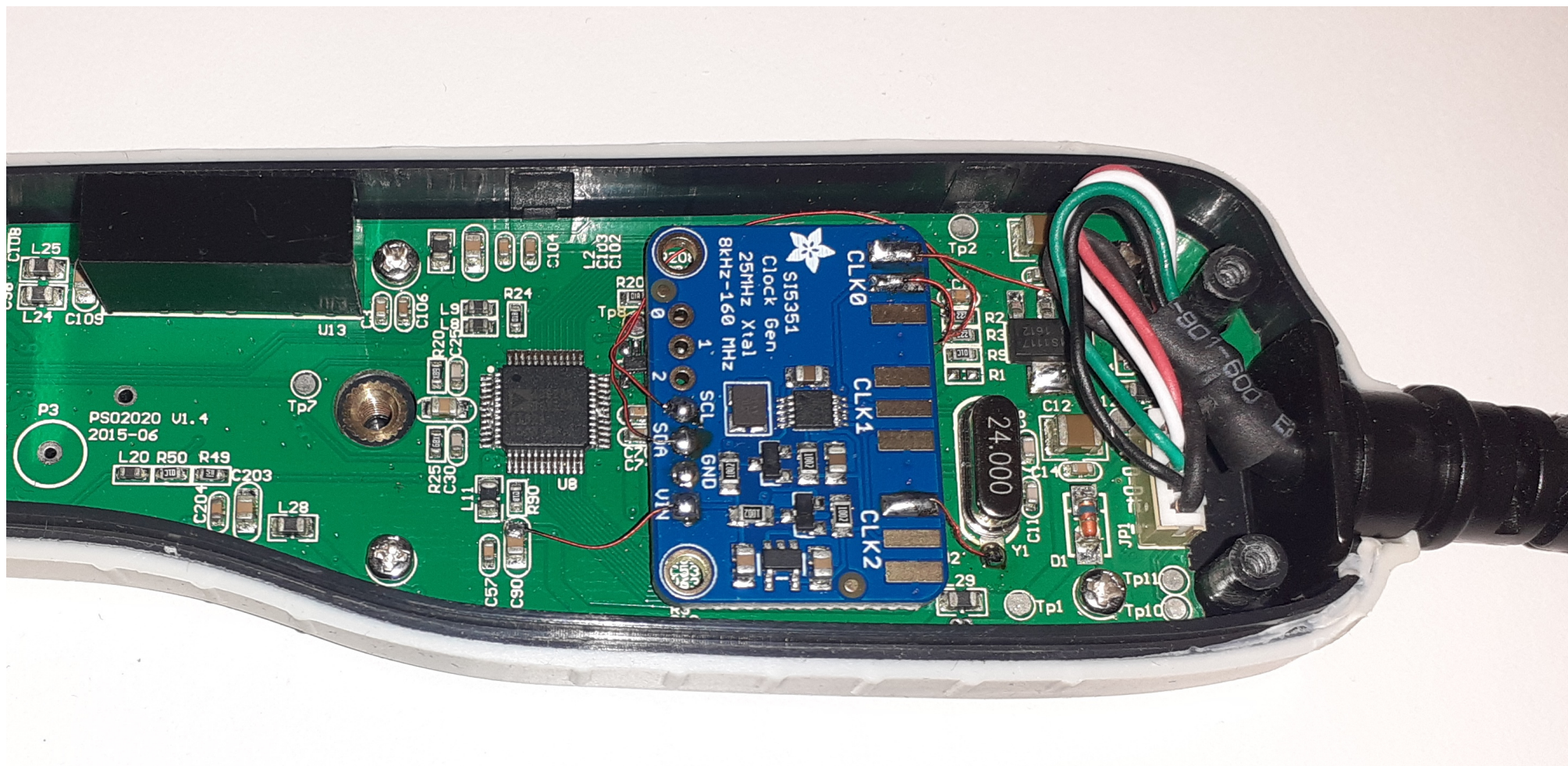
---

As a main clock for the interface you can select:

- 30 MHz
- 48 MHz (too fast for HS USB 2.0!)
- or add delay cycles
- IFCLK input

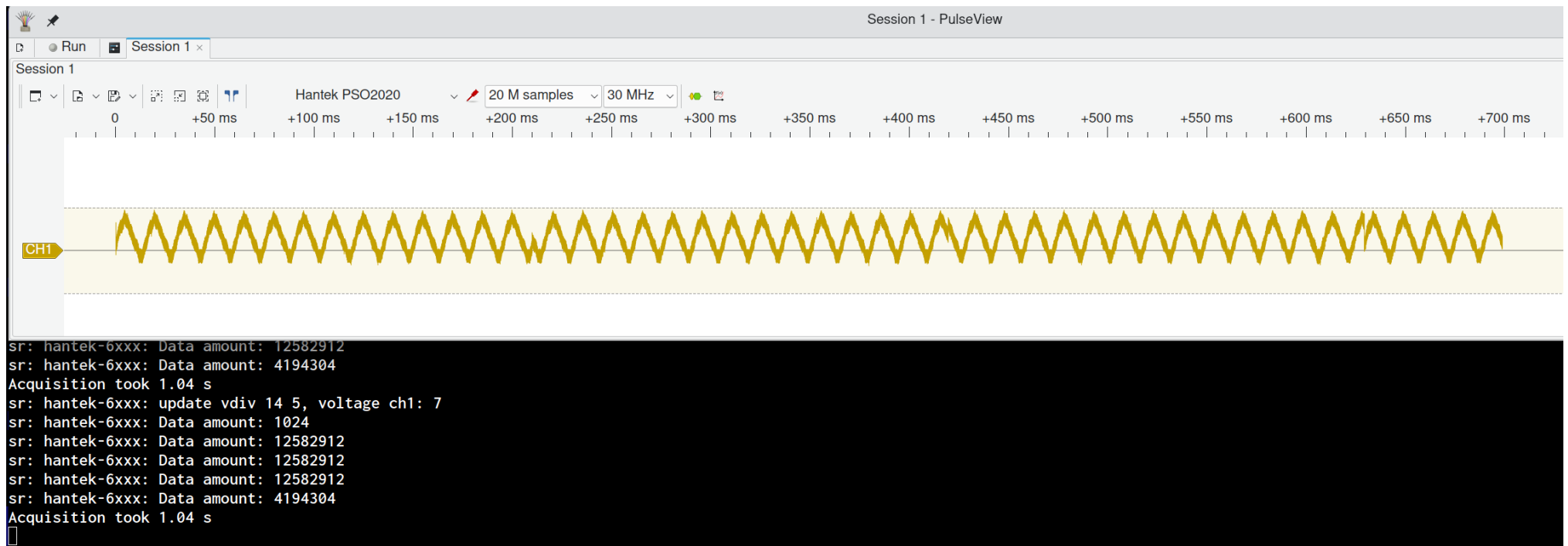
# Clock modification

---



# Sigrok

- FX2-based oscilloscopes are supported by Sigrok
- Use that to capture data stream?
  - This specific model was not supported yet by fx2lafw ⇒ added that
  - libsigrok only uses a single USB transfer for FX2 scopes...



# libfx2adc

---

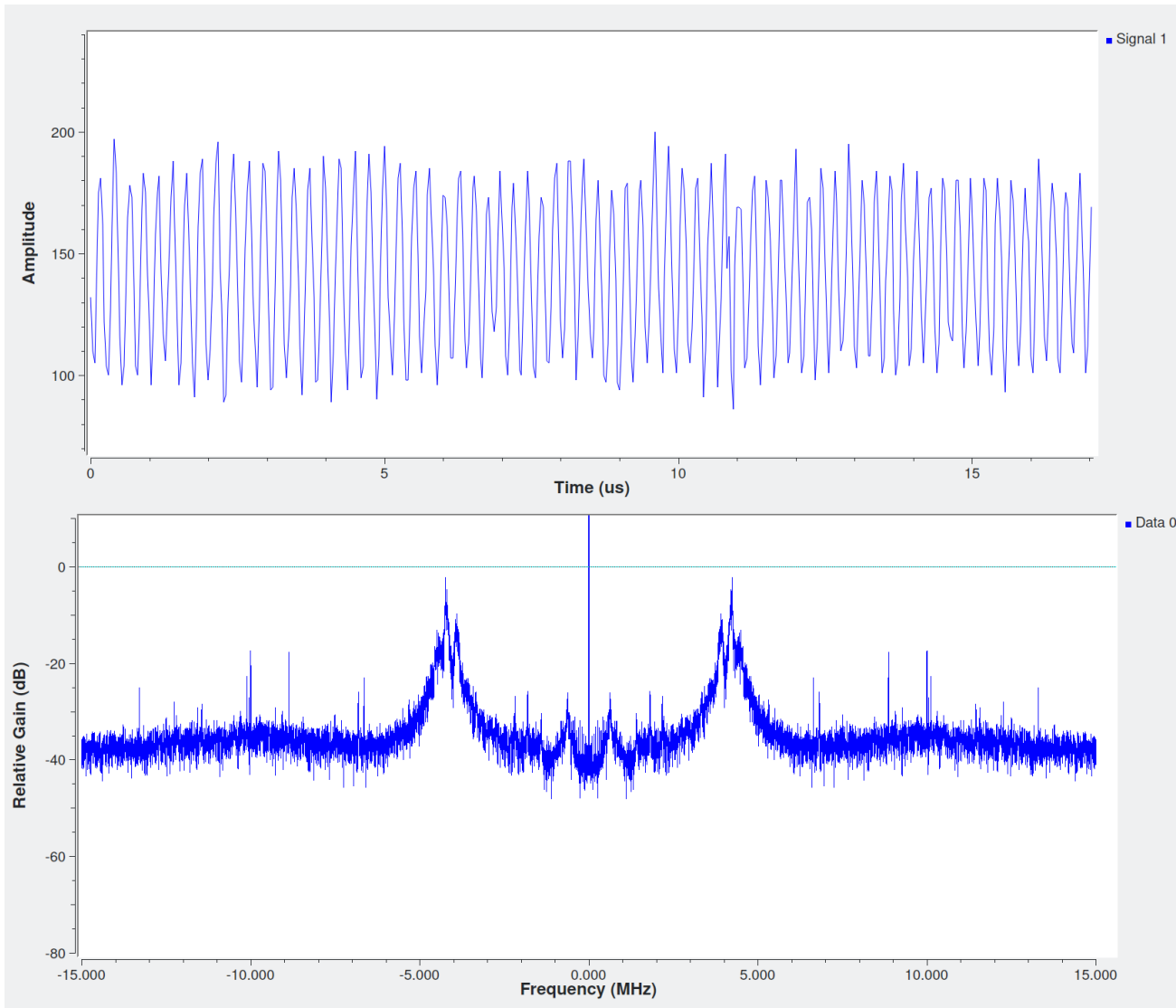
- Small library that loads (patched) fx2lafw and streams from the device
- Voltage divider (input gain) can be specified via commandline argument
- Checks if Si5351 is present, can use that to generate clock
- Uses AC coupling if present
- Usual rtl-sdr like tools:
  - fx2adc\_file
  - fx2adc\_tcp
  - fx2adc\_test

# VHS RF tap with USB oscilloscope

---

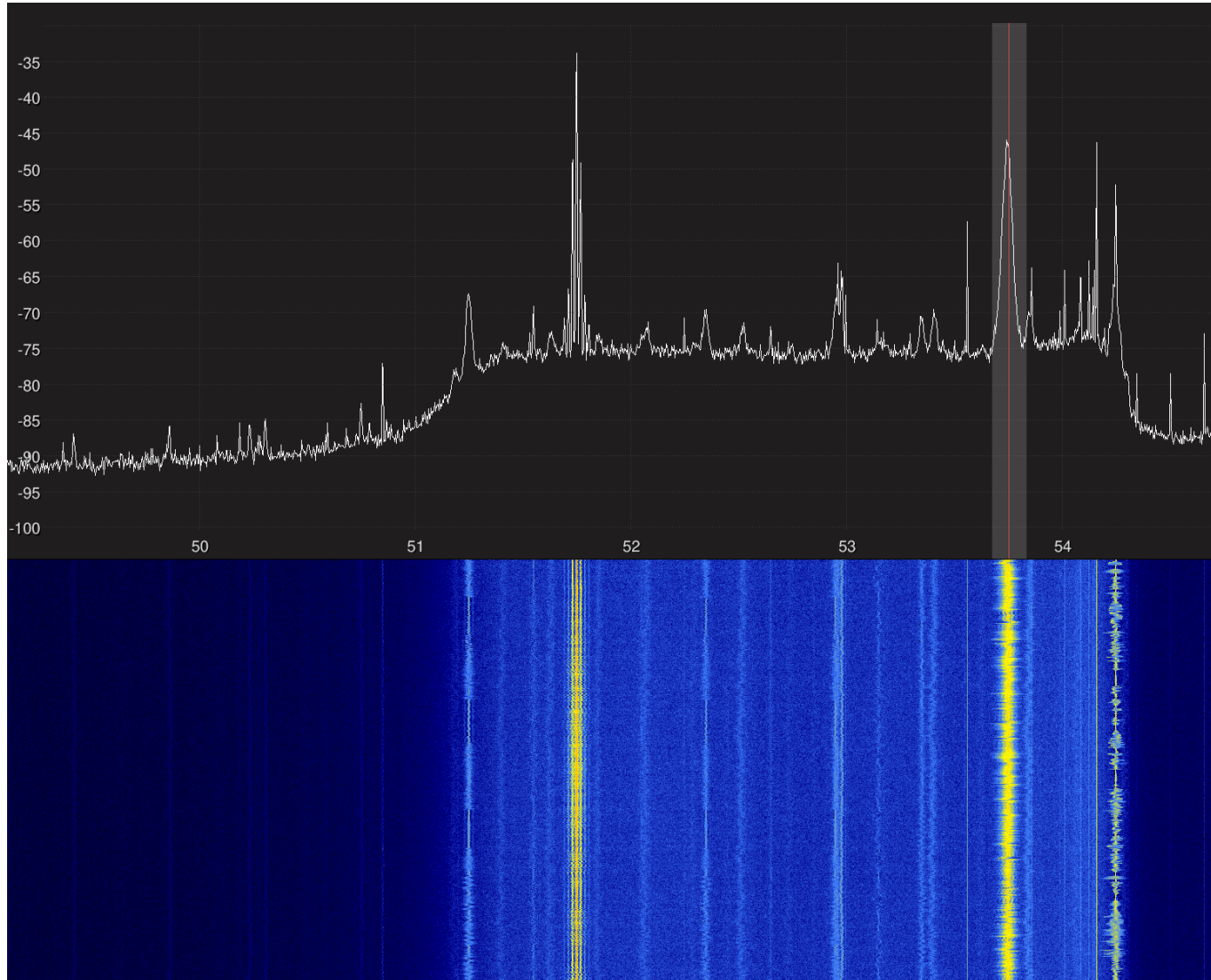


# VHS RF spectrum

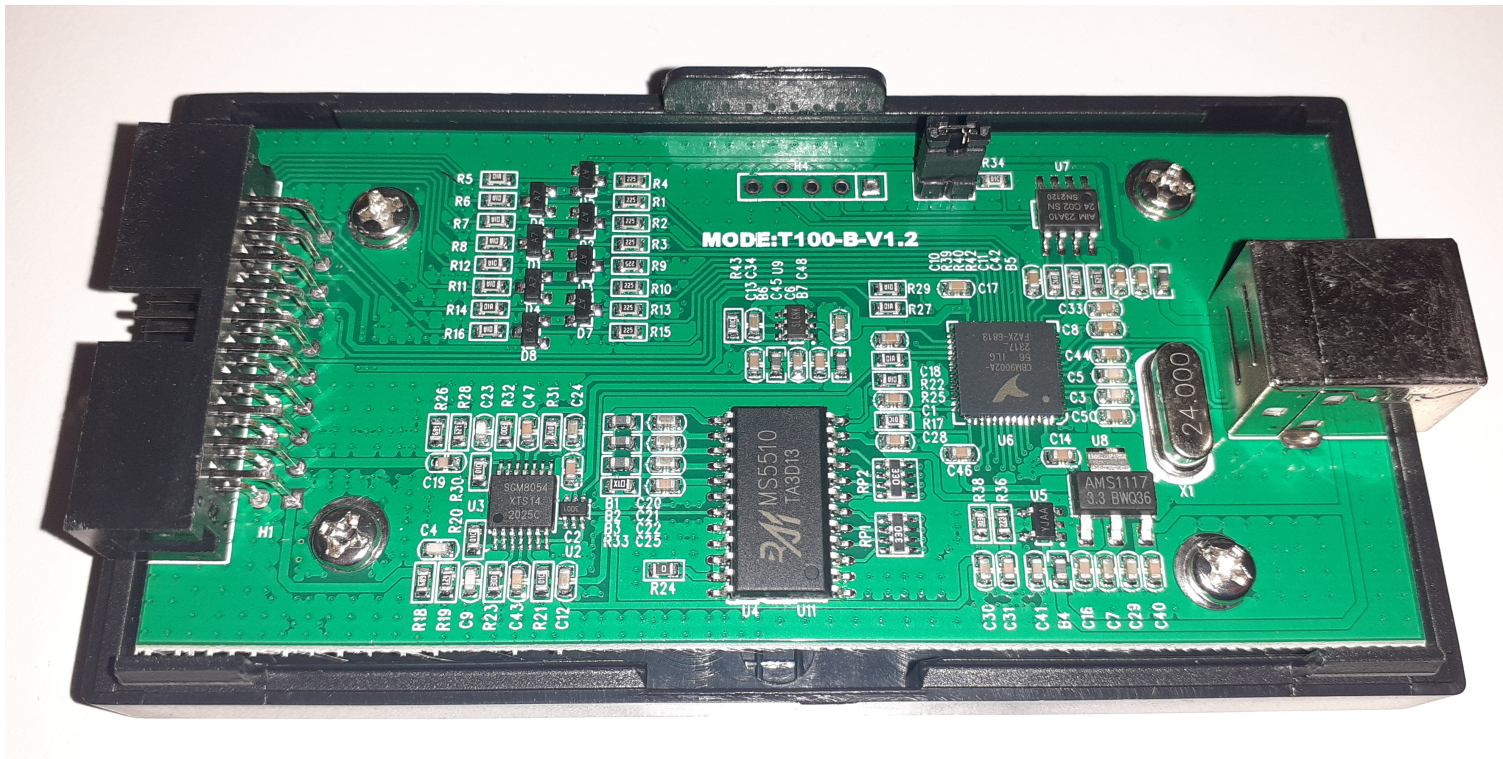


# fx2adc + R820T

---



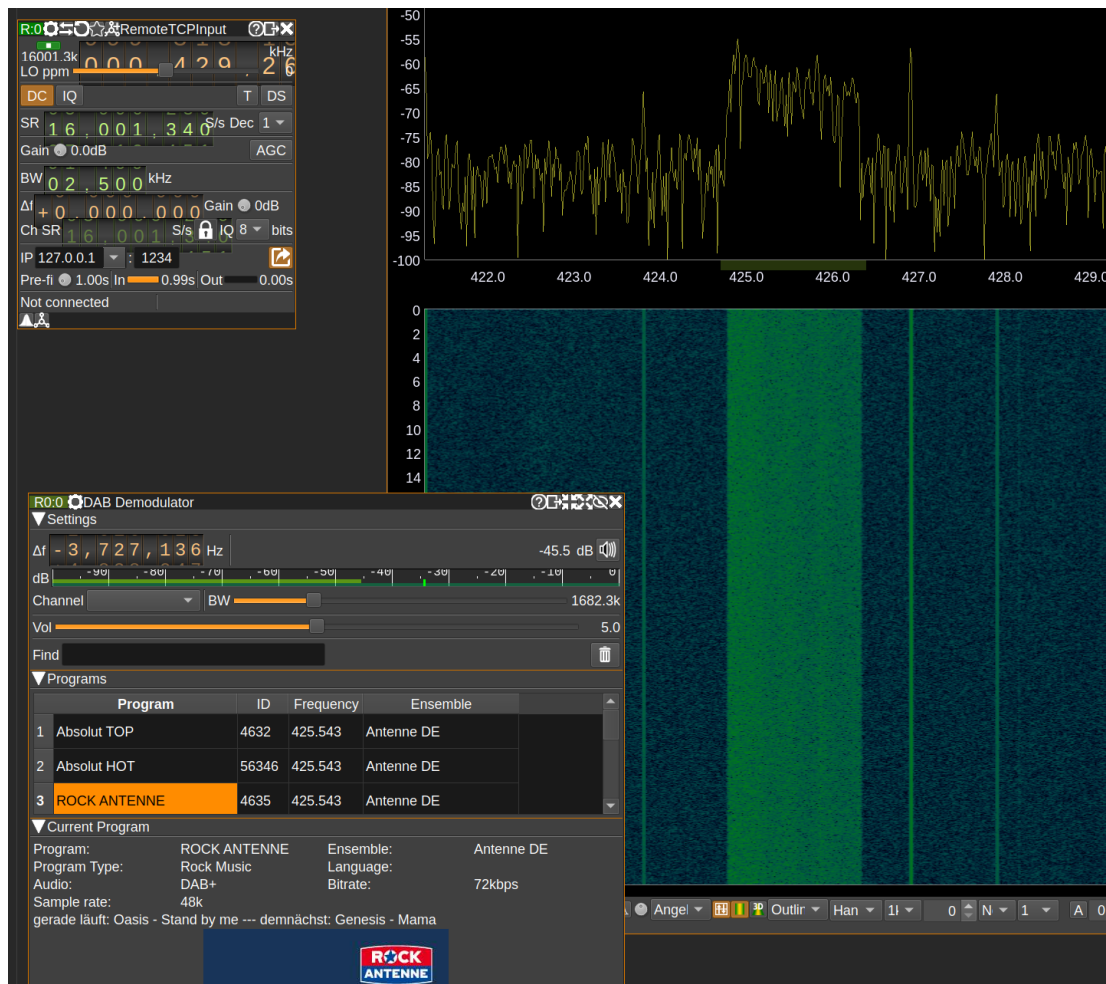
# FX2-based logic analyzer with analog input



- All chinese components, ~24 USD
- Unfortunately ADC is connected to second 8 bit port, so 16 MSPS max



# Listening to DAB with LHT00SU1 + R820T



# Summary

---

FX2-based oscilloscopes can be used for:

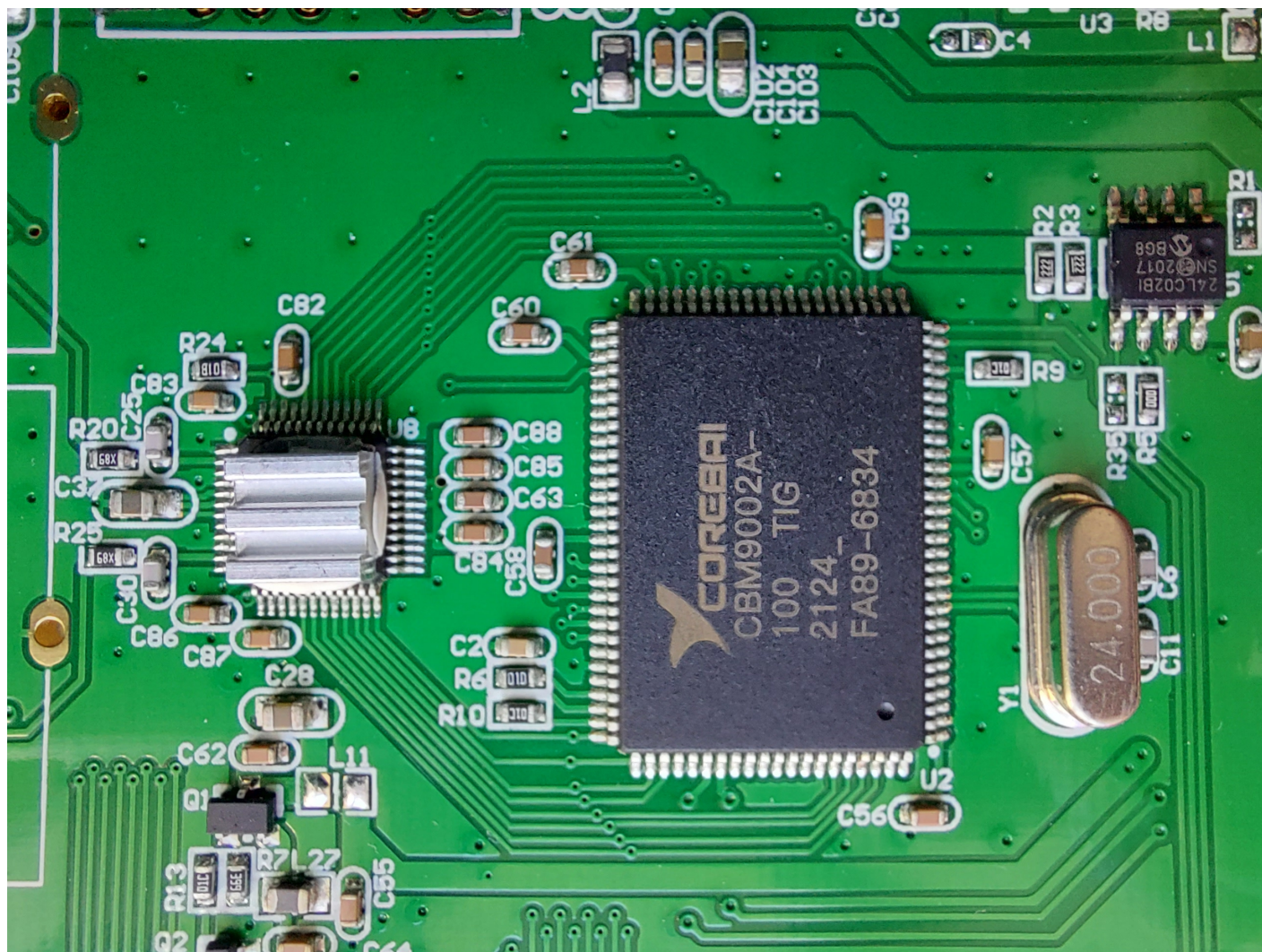
- extending bandwidth of rtl-sdr sticks
- direct sampling HF receiver (add some external LPF, amp)
- vhsdecode
- maybe scopehal + ngscopeclient?

However:

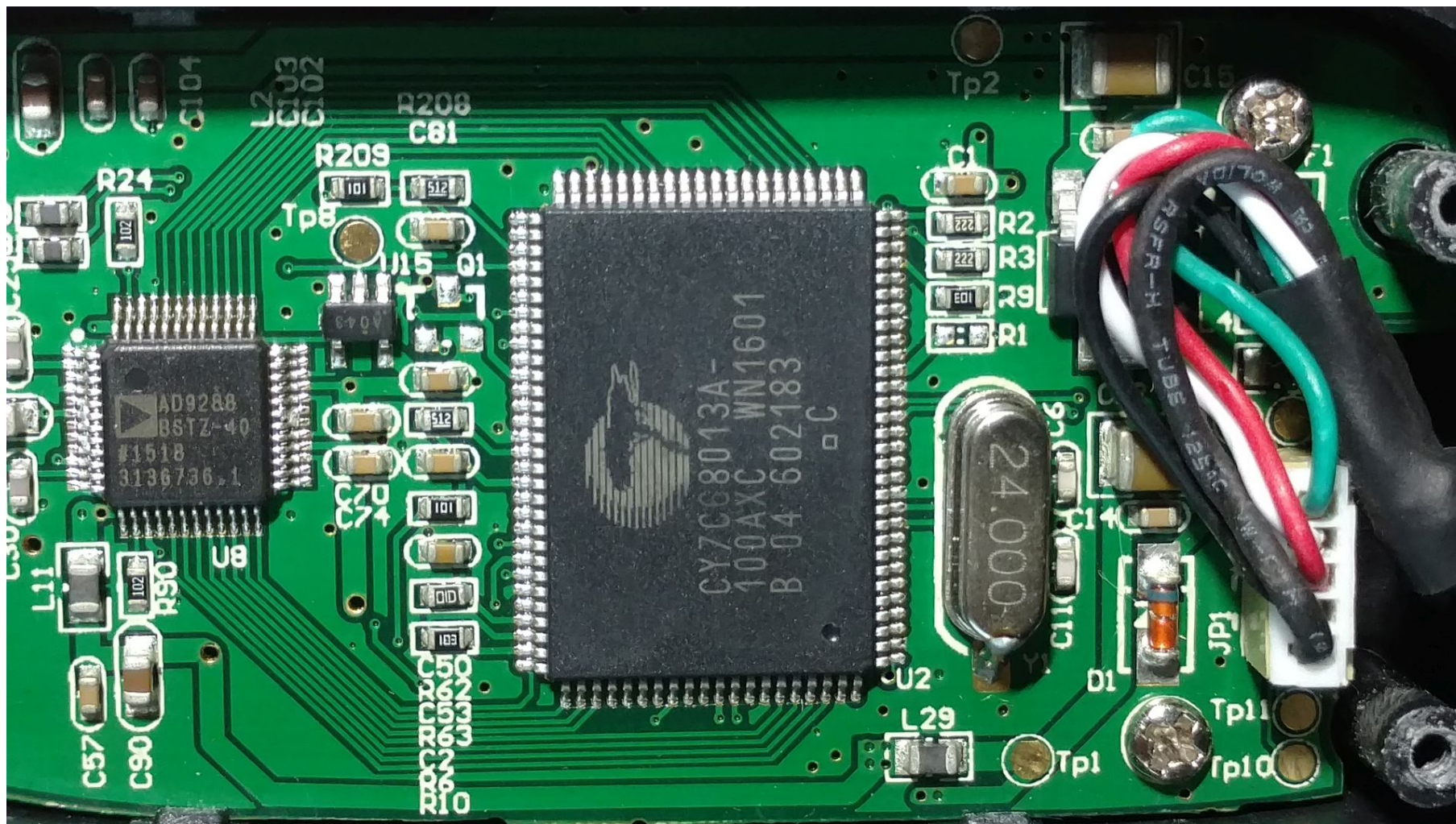
- need HW modification to get maximum sample rate
- more than one device connected to a single host don't work with 40 MSPS
  - seems to be a limitation of USB 2.0 host controllers..

# Can you spot the difference?

---



# Can you spot the difference?



# EOF

---

- More information:
- <https://github.com/steve-m/fx2adc>

## Other resources:

- [https://sigrok.org/wiki/Supported\\_hardware#Oscilloscopes](https://sigrok.org/wiki/Supported_hardware#Oscilloscopes)
  - <https://sigrok.org/wiki/Fx2lafw>
  - <https://github.com/oyvindln/vhs-decode>
  - <https://github.com/happycube/cxadc-linux3>
  - [https://gitlab.com/jorgem-dev/cx88\\_sdr](https://gitlab.com/jorgem-dev/cx88_sdr)
- 
- Questions?