

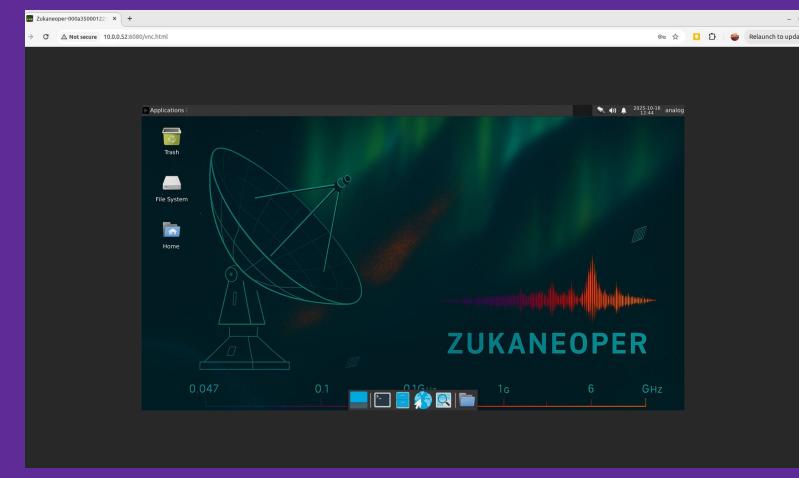
# Autonomous SDR based on Zynq/AD936x

## From a "Radio Peripheral" to an "Edge-Integrated SDR."

[Tezuka firmware](#) [Tezuka fpga](#) [Zukaneoper](#)



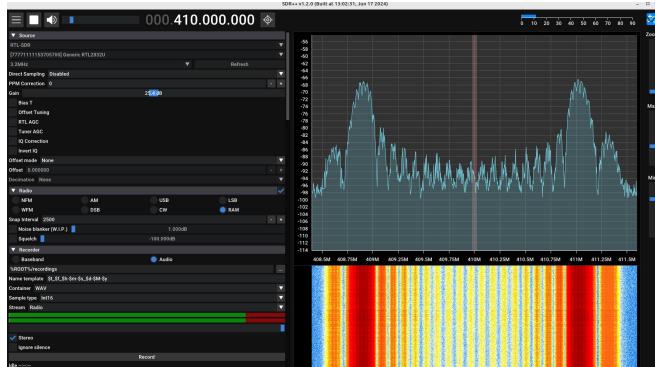
F5OEO Evariste  
[evaristec@gmail.com](mailto:evaristec@gmail.com)  
[github.com/F5OEO](https://github.com/F5OEO)



# Introduction



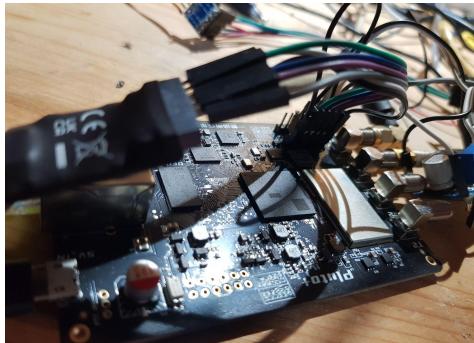
## SDR peripheral



## Host

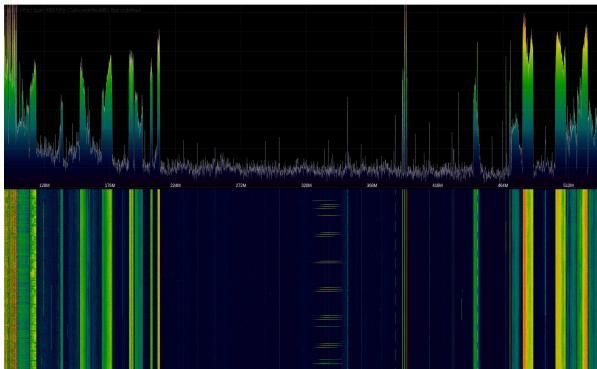
- SDR peripheral
- Software on host
- Link (USB, Network, PCIe)
- OS dependant

# Introduction



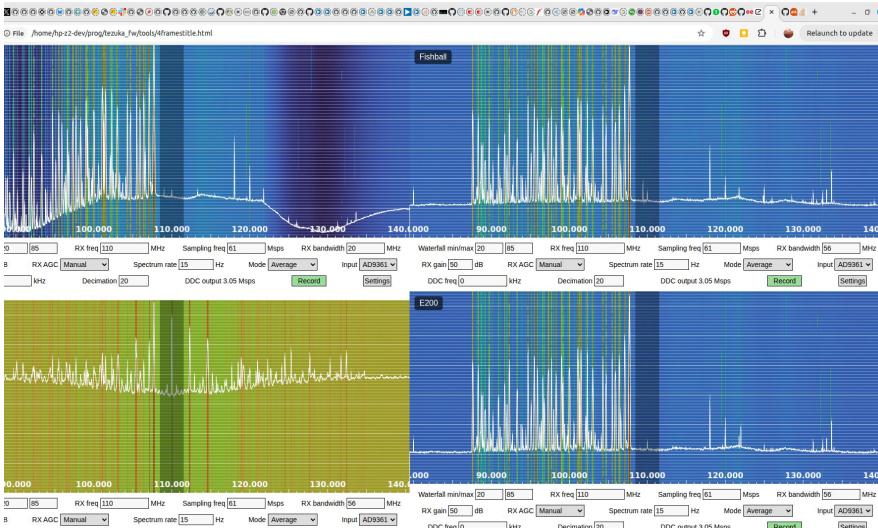
Embedded  
dsp

Agnostic  
viewer



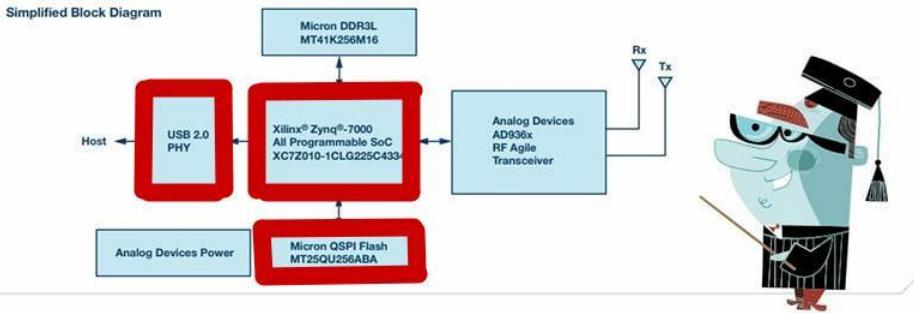
- More than I/Q gateway
  - Autonomous
  - No host required
  - Universal device viewer
-

# Talk plan

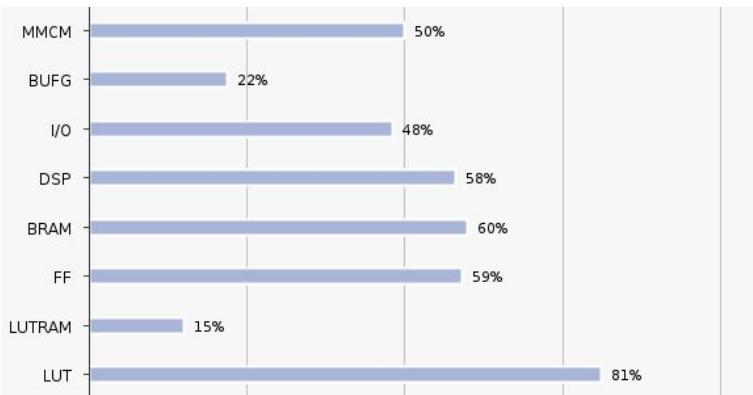


- PlutoSDR limits
- Enhancement of clones
- Tezuka firmware
- Zukaneoper spin-off
- Zero-Install
- Future
- Q&A

# PlutoSDR barriers



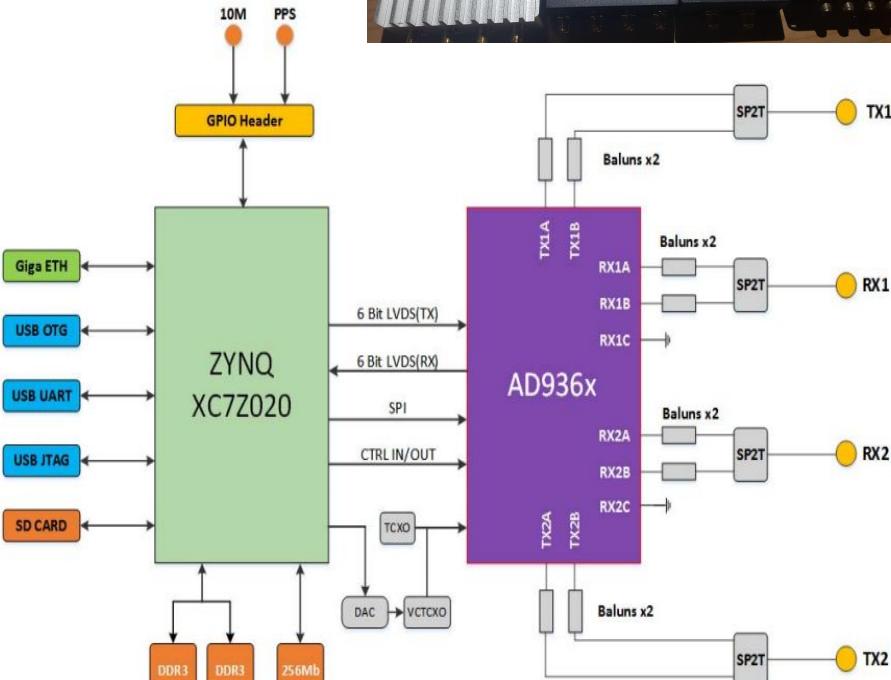
## FPGA 7010 utilization



## Characteristics

- 32MB QSPI flash
- No persistent until jffs
- USB bandwidth 3 MHz
- Hard to integrate custom software
- FPGA 7010 limited

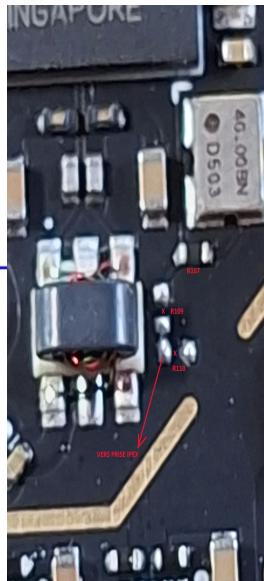
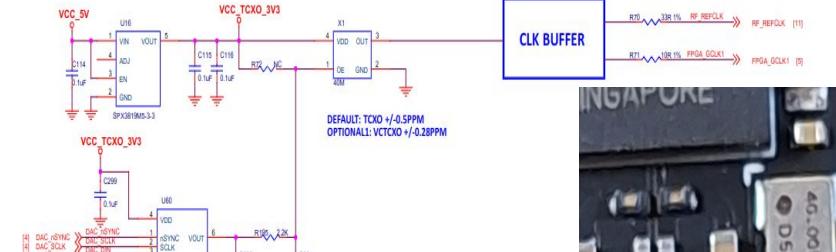
# Clones



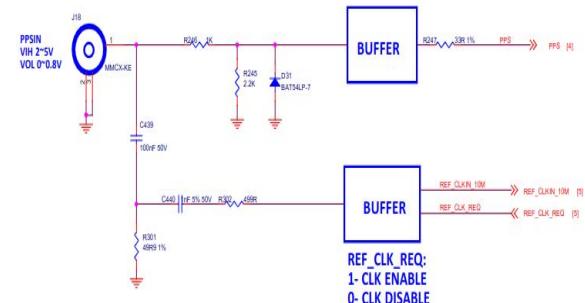
- SD card
- Gb Ethernet
- FPGA 7020
- USB serial debug
- Heterogeneous
- Cheaper
- Less documented

# Clones

## CLOCK



## PPS/10M



## Warning on external clk

- 40MHz input
- 10MHz/1pps generation
- Be prepared for soldering
- AD9361/AD9363

# Tezuka firmware

```
tezuka-fw/
├── Config.in          # Root Buildroot package config (sources all package/*Config.in)
├── external.desc       # Declares BR2_EXTERNAL_PLUTOSDR for Buildroot
├── external.mk         # Includes all package/*.mk files
├── sourceme.first      # Sets BR2_EXTERNAL env var (source this first)
├── getbuildroot.sh     # Downloads & patches Buildroot 2025.05
├── make_all.sh          # Builds all board targets sequentially
├── update_bitstream.sh # FPGA bitstream update helper
├── README.md
└── LICENSE

-- configs/              # Buildroot defconfigs (one per target board)
    ├── pluto_maiasdr_defconfig
    ├── plutoplus_maiasdr_defconfig
    ├── e200_maiasdr_defconfig
    ├── e310_maiasdr_defconfig
    ├── libre_maiasdr_defconfig
    ├── fishball_maiasdr_defconfig
    ├── fishball_maiasdr_7020_defconfig
    ├── fishball_mini_defconfig
    └── signalsdrpro_defconfig

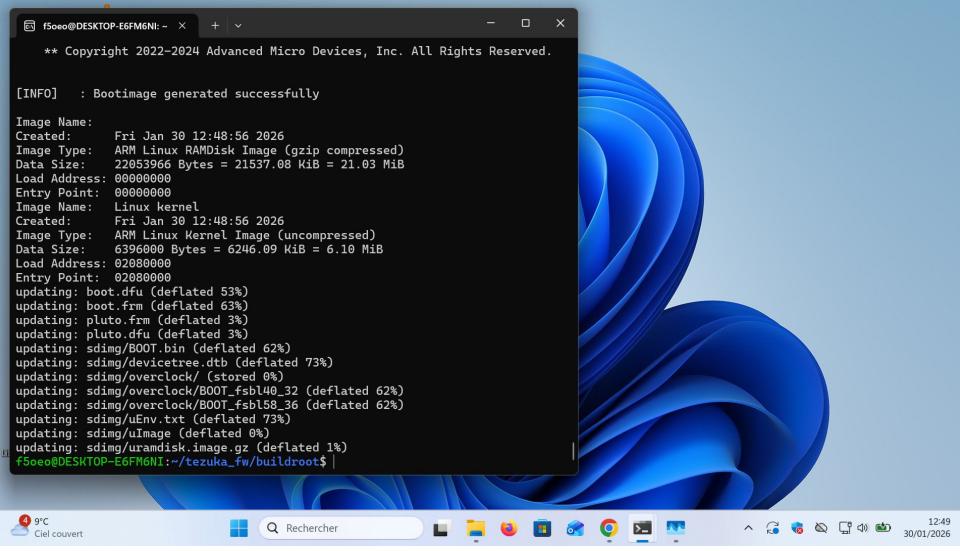
-- board/tezuka/
    ├── common/           # Shared: rootfs overlays, kernel patches, post-build/post-image script
    │   ├── pluto/          # Per-board: DTS, bitstreams, U-Boot config, kernel config, uboot-env
    │   ├── plutoplus/
    │   ├── e200/
    │   ├── e310/
    │   ├── libre/
    │   ├── fishball7010/
    │   ├── fishball7020/
    │   └── signalsdrpro

-- package/
    ├── *_fpga/           # 35+ custom Buildroot packages
    ├── maia-kmod/         # Maia SDR kernel module
    ├── maia-httpd/        # Maia HTTP daemon
    ├── maia-wasm/         # Maia WebAssembly frontend
    ├── maiasdr-fw/        # Maia SDR firmware meta-package
    ├── sdr_usb_gadget/
    ├── tezuka_tools/
    ├── soapySDR/
    ├── soapyplutosdr/
    ├── kalibrate/
    ├── hamlib/
    ├── civetwebws/
    ├── srt/
    ├── gr-dvbs2rx/
    ├── gr-satellite/
    ├── futuresdr/
    ...
    └── app/               # Custom C applications (simple Makefiles, link libiio/libcivetweb)
        ├── pluto_rx/
        ├── pluto_tx/
        ├── sweep/
        └── fft-client/    # FFT sweep with WebSocket output + web UI (www/)


```

- Detached from ADI
  - 100% Buildroot
  - Linux 6.1
  - Universal Rootfs
  - Custom FPGA
  - SD and Flash target
  - Github CI build
-

# Build it yourself



```
f5oo@DESKTOP-E6FM6NI:~ + □ ×
** Copyright 2022-2024 Advanced Micro Devices, Inc. All Rights Reserved.

[INFO] : Bootimage generated successfully

Image Name:           Fri Jan 30 12:48:56 2026
Created:             Fri Jan 30 12:48:56 2026
Image Type:          ARM Linux RAMDisk Image (gzip compressed)
Data Size:            22053966 Bytes = 21537.08 KiB = 21.03 MiB
Load Address:        00000000
Entry Point:         00000000
Image Name:          Linux kernel
Created:             Fri Jan 30 12:48:56 2026
Image Type:          ARM Linux Kernel Image (uncompressed)
Data Size:            6396000 Bytes = 6246.09 KiB = 6.10 MiB
Load Address:        02080000
Entry Point:         02080000
updating: boot.dfu (deflated 53%)
updating: boot.frm (deflated 63%)
updating: pluto.frm (deflated 3%)
updating: pluto.dfu (deflated 3%)
updating: sdimg/BOOT.bin (deflated 62%)
updating: sdimg/devicetree.dtb (deflated 73%)
updating: sdimg/overclock/ (stored 0%)
updating: sdimg/overclock/BOOT_fsb140_32 (deflated 62%)
updating: sdimg/overclock/BOOT_fsb158_36 (deflated 62%)
updating: sdimg/uEnv.txt (deflated 73%)
updating: sdimg/uImage (deflated 0%)
updating: sdimg/urandisk.image.gz (deflated 1%)
f5oo@DESKTOP-E6FM6NI:~/tezuka-fw/buildroot|
```

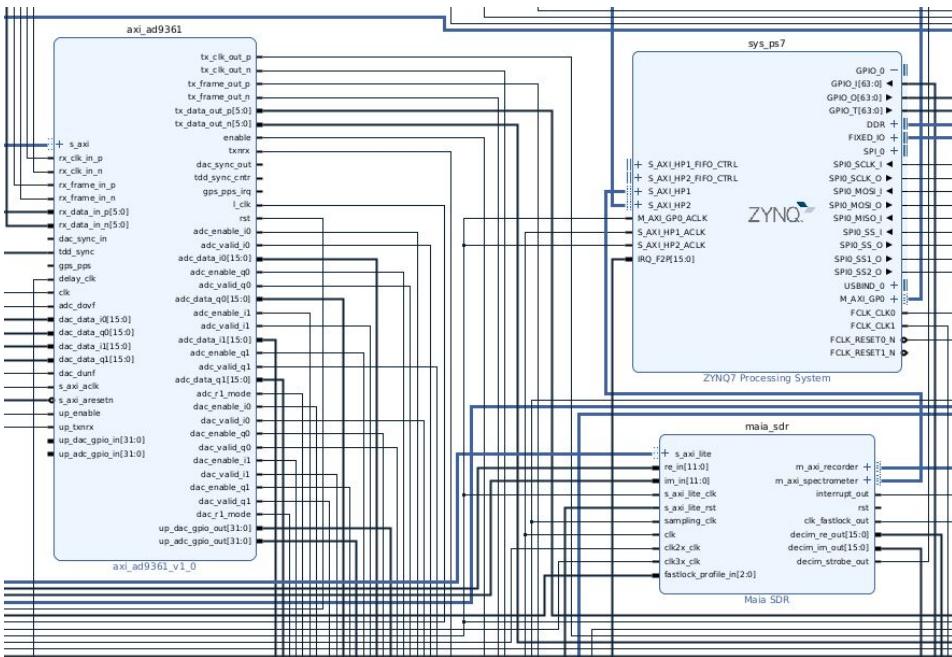
4 9°C Ciel couvert

Rechercher

12:49 30/01/2026

- Git clone
- Install minimal depends
- Ubuntu 22.04 based
- But also Windows (wsl)
- Update with scp

# Tezuka FPGA



Xilinx Vivado 2023.1

# Maia-sdr based with iio

- FFT
  - Complex IQ 12/8 bits
  - Decimation
  - Synchronized sweep
  - Overclocking
  - LVDS
  - 2R2T

# Tezuka linux kernel

## Kernel Source & Version

- Linux 6.1 from ADI fork ([analogdevicesinc/linux.git](#)), commit 04fbdbb433f...
- ARM Cortex-A9 with NEON/VFP, SMP, preemption enabled

## Configuration Hierarchy

```
common/kernel/zynq_pluto_linux_defconfig    ← base (O3, full features)
+ board/<variant>/kernel/fragment/frag1.config ← per-board overrides (UART, MACB)
```

## Kernel Patches (applied to all boards)

0002-extend\_freq : Extends AD9363 frequency range to 46.875 MHz-6 GHz

0003-Perf-spectre : Spectre mitigations + performance

0004-ad5660 : AD5660 DAC driver support

0005-maiasdr : Exports ARM cache flush functions for Maia SDR kmod |

## Device Trees

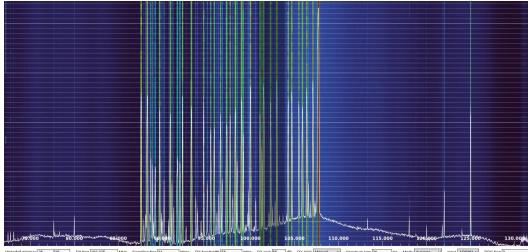
Each board has its own DTS set in board/tezuka/<variant>/dts/:

- zynq-7000.dtsi — shared Zynq SoC base
- zynq-<board>.dtsi — board-specific peripherals (AD9363 IIO, clocks, GPIOs, Ethernet PHY)
- zynq-<board>.dts — top-level DTS including the above

U-Boot has separate DTS files in u-boot-dts/.

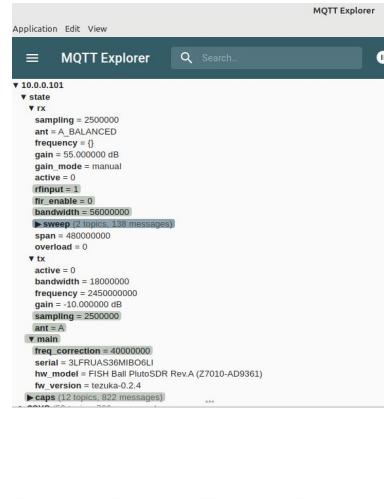
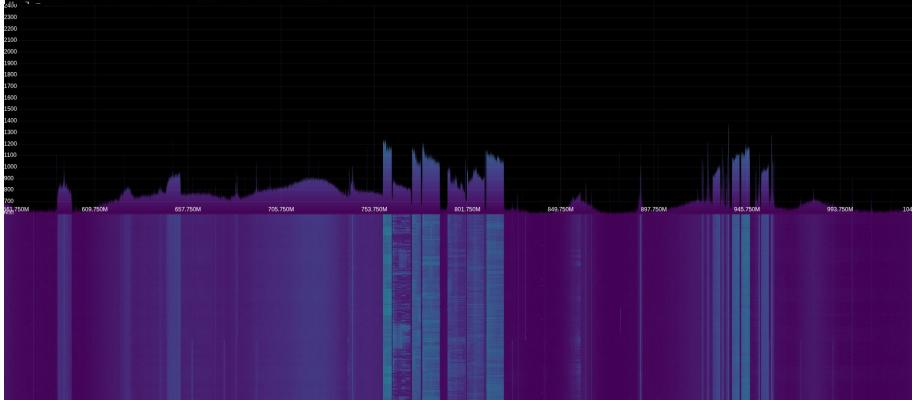
- SD Boot
- Rootfs on RAM
- Device tree by board
- NTFS, PPS
- Extended usb drivers (wifi, gps, audio)
- Native frequency extension (47Mhz-6Ghz)

# Tezuka rootfs



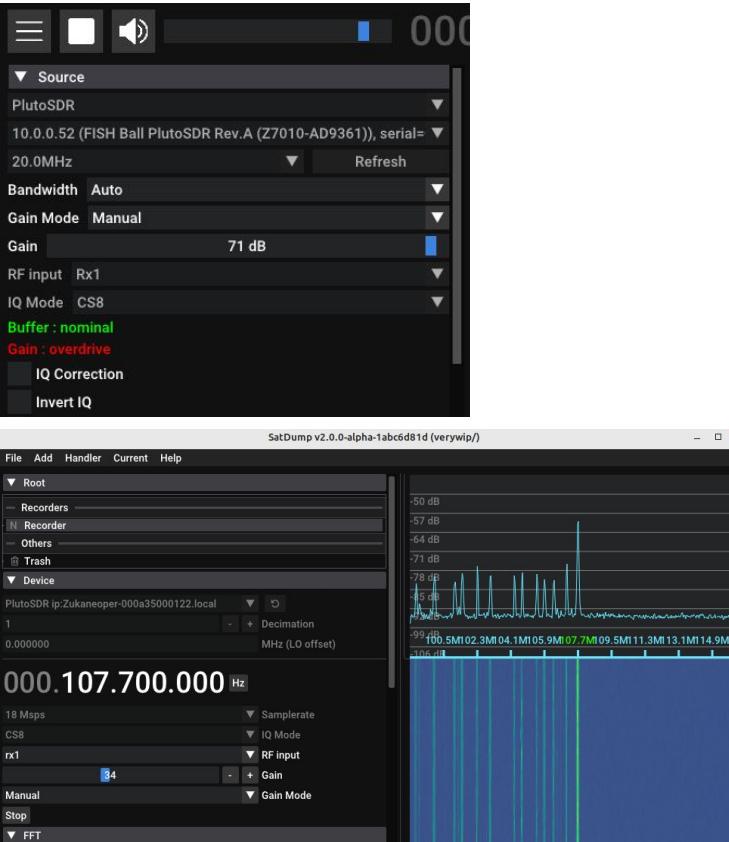
```
Results (100 valid bursts out of 494 attempts)
-----
average           [min, max]      (range, stddev)
    74Hz          [2, 139]        (137, 35.620094)
overruns: 0
not found: 393
```

Average Error: 0.081 ppm (80.686 ppb)



- Waterfall server
  - Sweep
  - High bandwidth CS8
  - MQTT server
  - Calibration
  - RX1/RX2
  - NTP
  - PTT on GPIO

# Tezuka for host



- [SoapySDR](#)
- [SatDump](#)
- [SDR++](#)
- SdrAngel (partial)
- [Maia python library](#)
- SigDigger
- ...

# Tezuka community

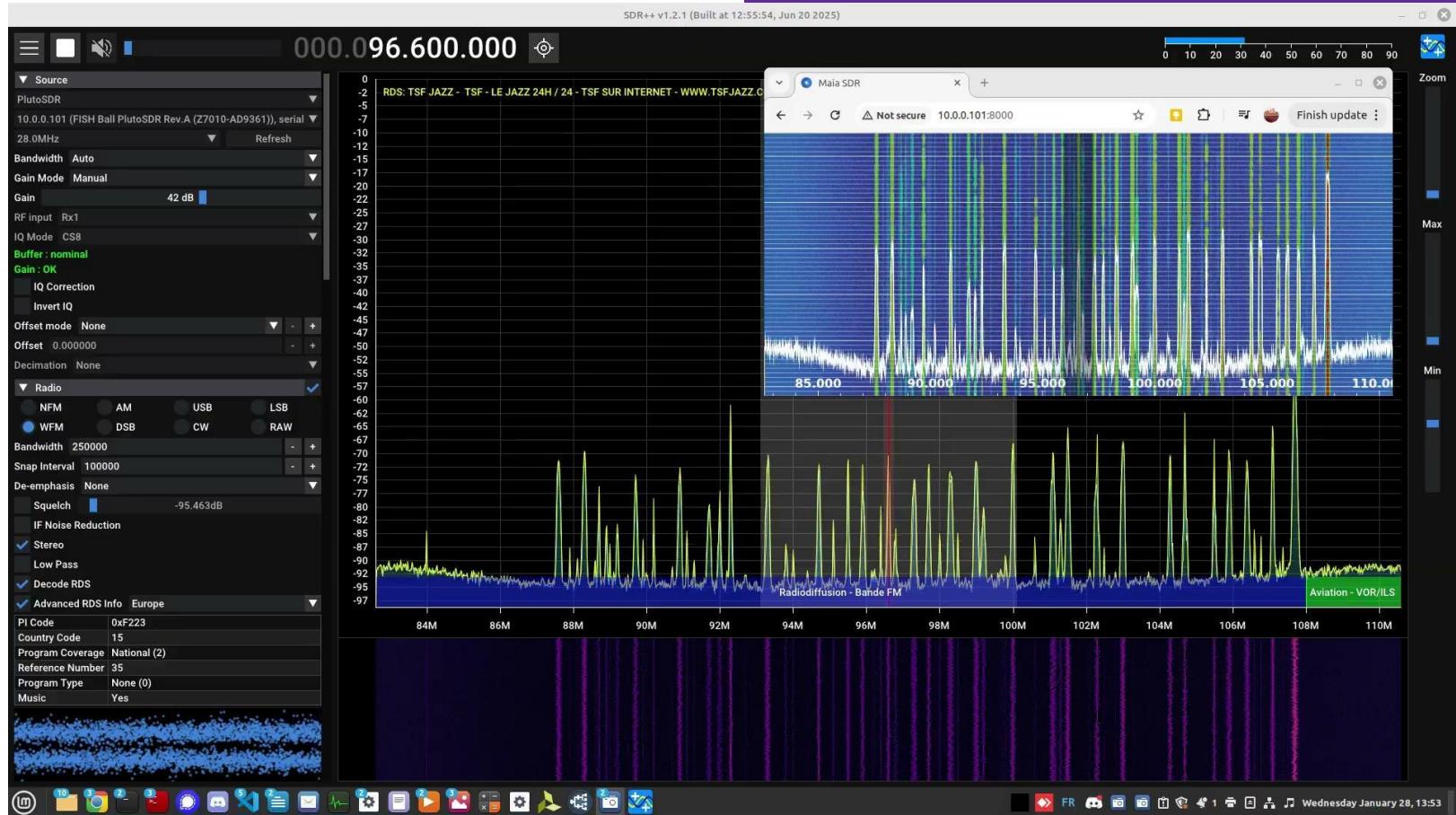
The screenshot shows the GitHub repository for FSQEo / tezuka.fw. The Issues tab is selected, displaying 54 open issues. The issues are listed in descending order of age. The first few issues include:

- Sd image not boot after 0.0.9 (opened Feb 13, 2022)
- Can't boot using HamGeek 70MHz-8GHz Zynq7010+AD9363 (help wanted, opened Feb 28, 2022)
- PlutoSDR Nano support (enhancement, opened Mar 1, 2022)
- Problems to Update the P+ - Limitations on PCB-Revisions? (pluto+, question, opened Mar 1, 2022)
- No TX out with SDR-Console Software SSB (question, opened Mar 2, 2022)
- Can't boot libresdr HAMGEEK AD936X ZYNQSDR on rev 0.2.4 Debian (Could not replicate issue, opened Mar 2, 2022)
- TX\_LO (altvoltage1) powerdown handling on plutoplus – is there a cleaner solution? (enhancement, question, opened Mar 2, 2022)
- Real Time Sample support (enhancement, opened Mar 2, 2022)
- PLUTO.ZIP IP Connection Fails (bug, Should be fixed, opened Dec 29, 2022)
- LibreSDR Rev5, 2R2T and 10M Ext. Ref Issues (opened Dec 22, 2022)
- 10MHzリファレンスロック入力 10MHz reference clock input (opened Dec 19, 2022)

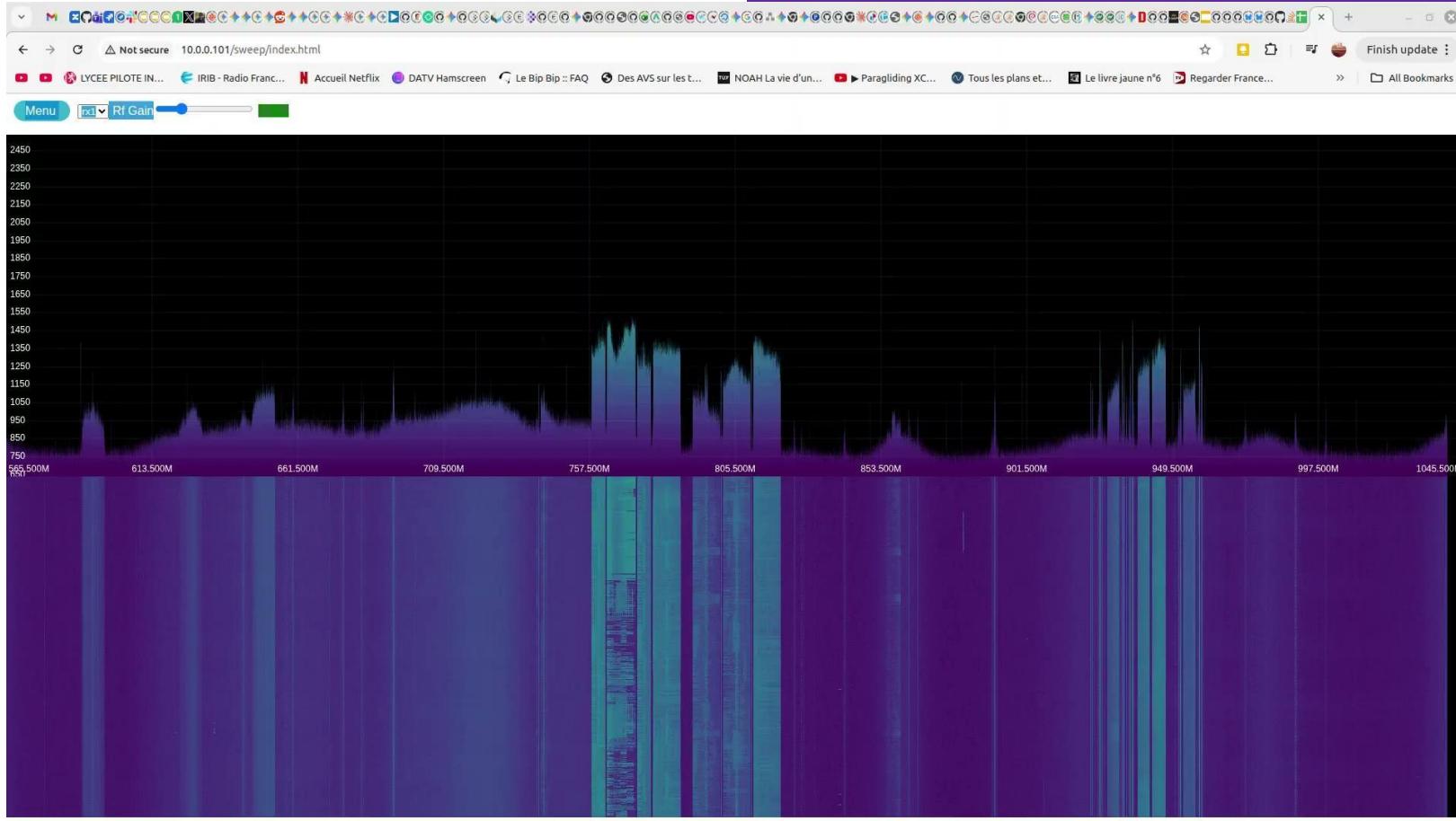
- Nearly 10K downloads
- Active github issues
- Contributors
- Manufacturer samples

(Plutopplus,antsdr,signalens)

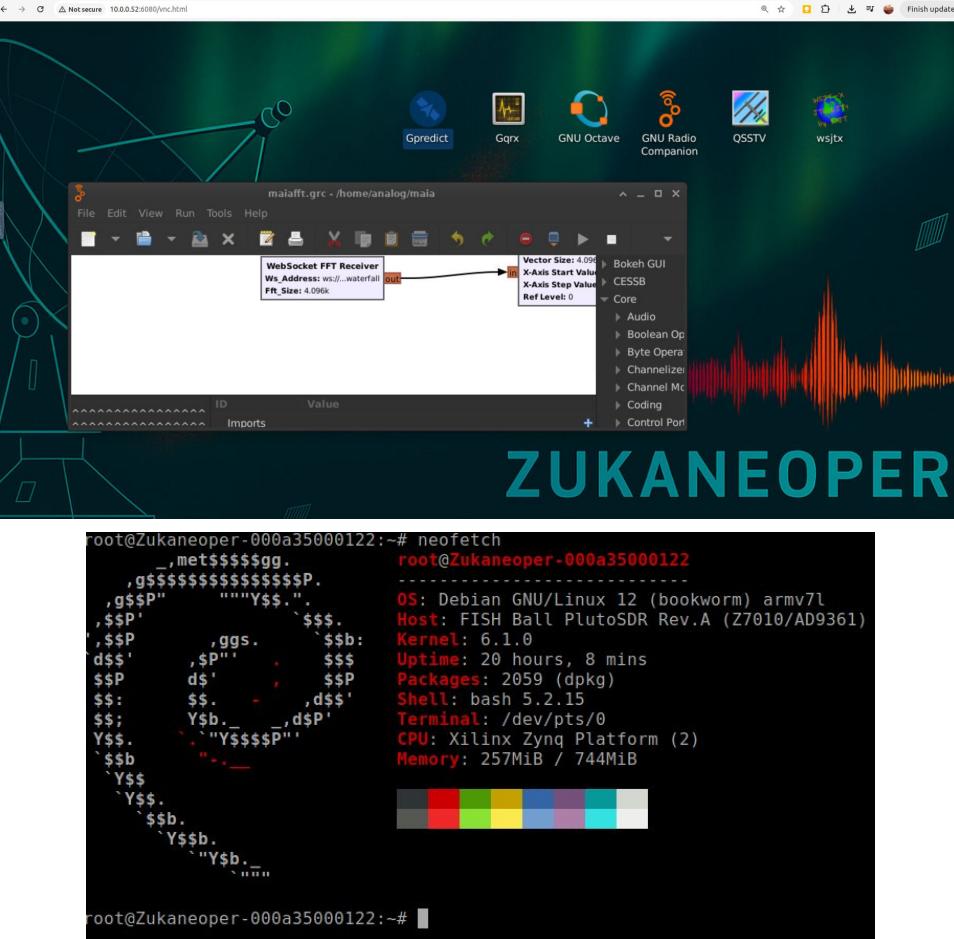
# DEMO



# DEMO



# Zukaneoper

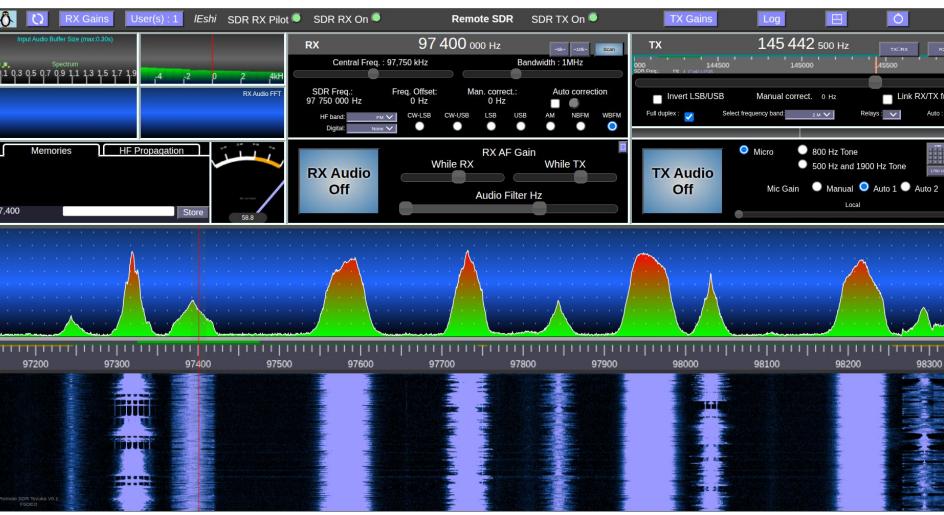


- Tezuka extension
- Extended rootfs on SD
- Persistent
- Debian 12 based
- Install scripts and Qemu
- VNC access with web
- Pre installed packages

# Zero install

```
root@Zukaneoper-000a35000122:~# gcc --version
gcc (Debian 12.2.0-14+deb12u1) 12.2.0
Copyright (C) 2022 Free Software Foundation, Inc.
This is free software; see the source for copying conditions. There is NO
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.

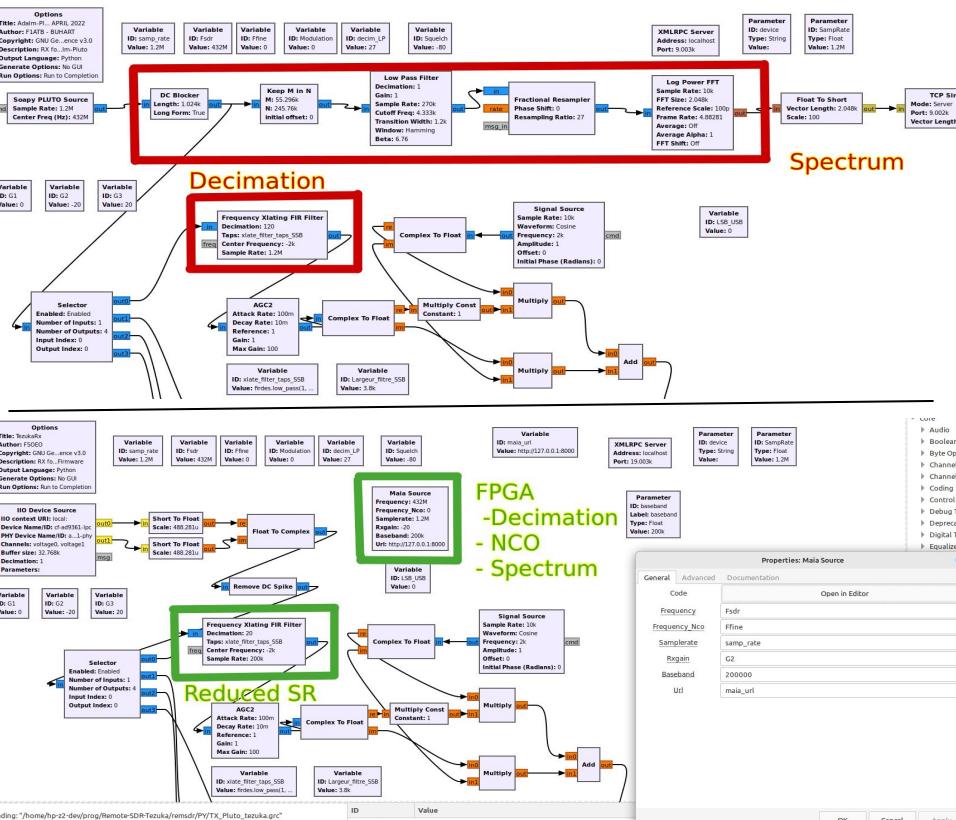
root@Zukaneoper-000a35000122:~# python3 --version
Python 3.11.2
root@Zukaneoper-000a35000122:~# luaradio --version
Parsing /proc/self/auxv to extract ELF hwcaps!
Parsing /proc/self/auxv to extract ELF hwcaps!
Parsing /proc/self/auxv to extract ELF hwcaps!
LuaRadio 0.11.0 - Vanya A. Sergeev. https://luaradio.io
root@Zukaneoper-000a35000122:~# █
```



- Can compile on target !
- Python3
- GNU Radio & examples
- GqrX/Gpredict
- RTL433
- ReadDsb
- LUA Radio
- Remote-SDR ...

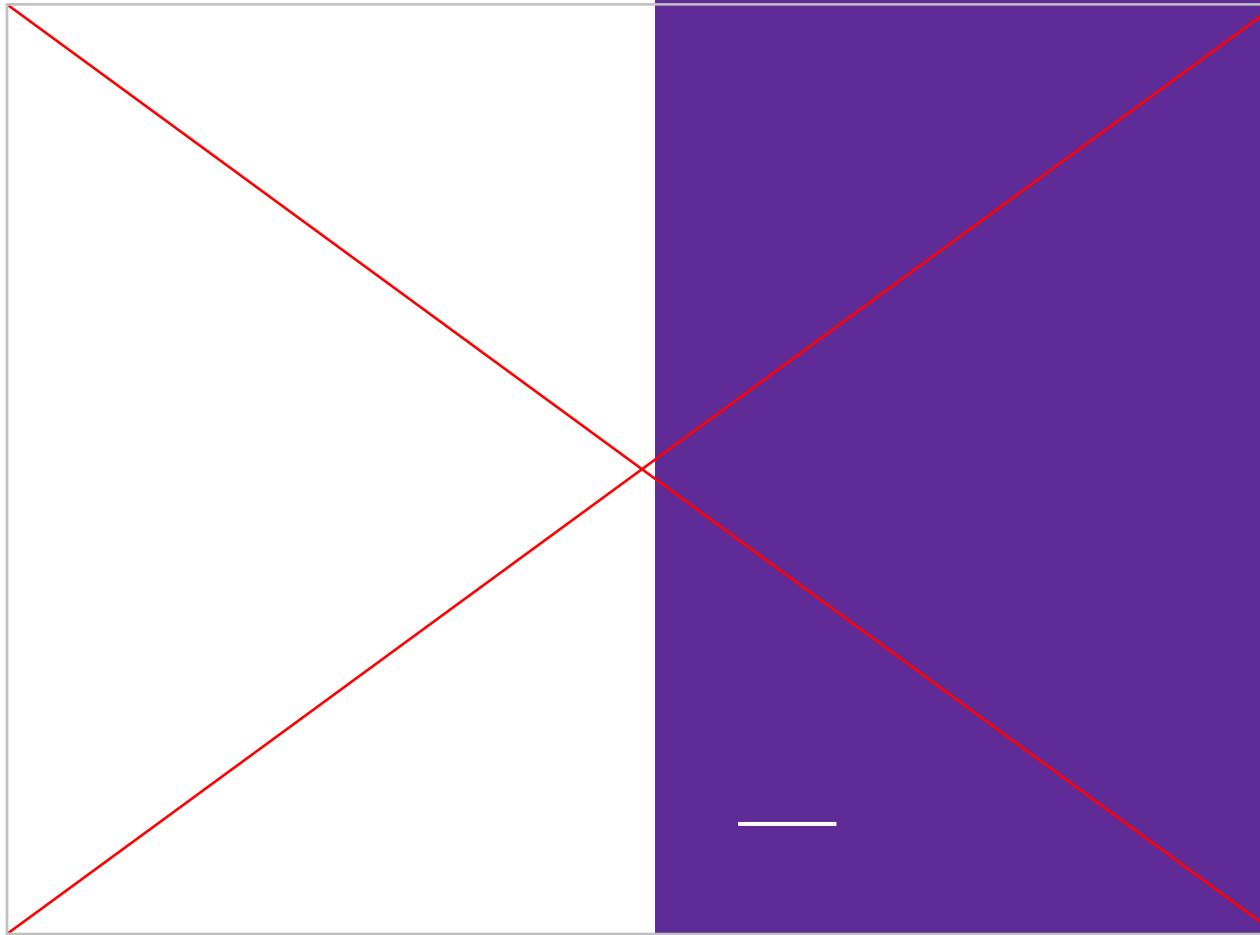
# Don't tax the CPU !

# Use the FPGA



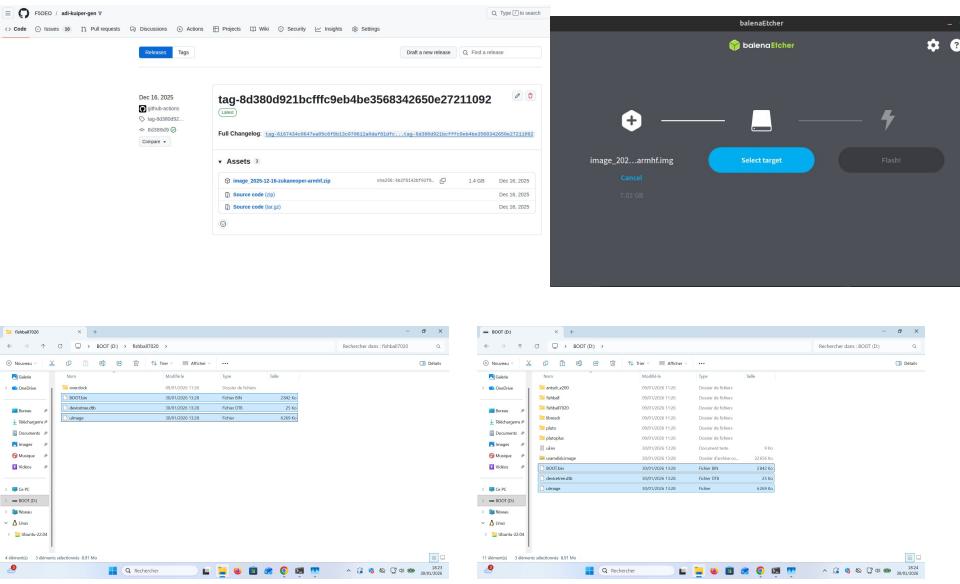
- Decimation
  - Spectrum
  - GRC with maia-python
  - Proof of concept

# DEMO



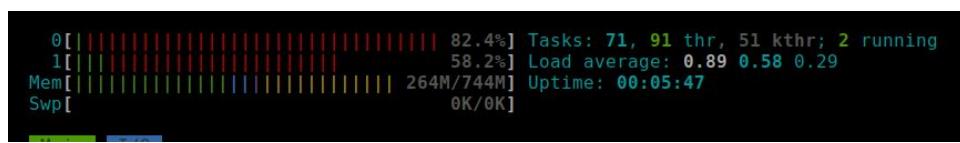
Only web client

# Newbie Installation



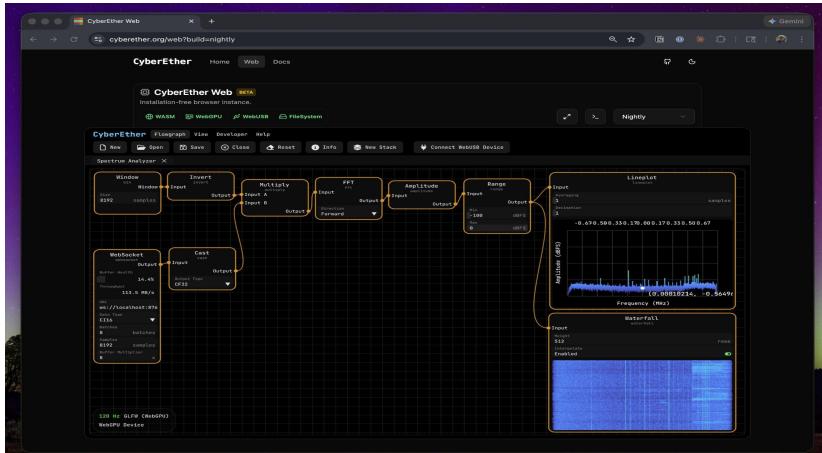
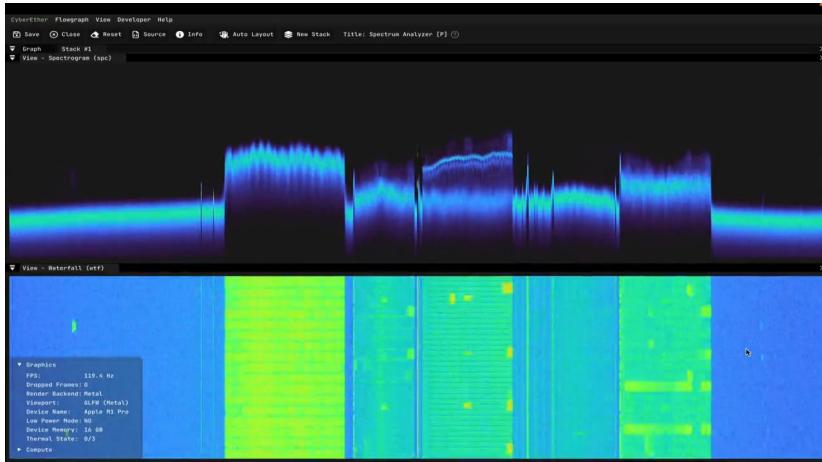
- Download release
- ISO writing on SD
- Copy board to boot
- Set your network
- Use it (or debug it)

# Limits



- Non agnostic gateway
- Get my DSP back
- AD936x drawbacks
- IIO CPU usage

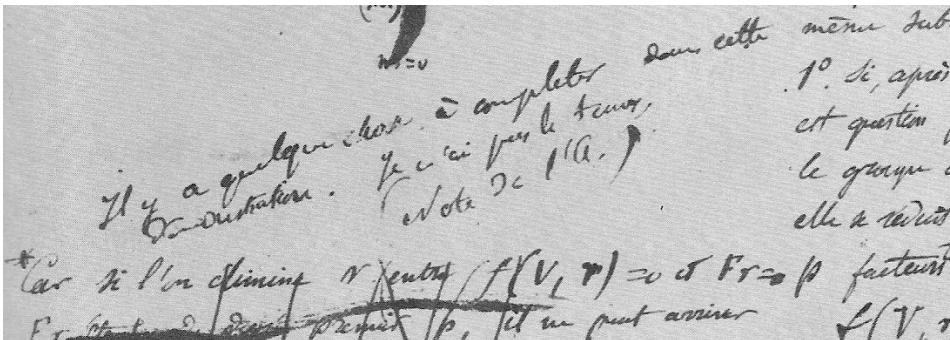
# Future ?



- WebSocket based IQ
- CyberEther WebGPU
- DSP on browser
- Modular FPGA build
- GPIOs to extend uses
- Port to Redpitaya

# In conclusion

"Il y a quelque chose à compléter dans cette démonstration. Je n'ai pas le temps"  
Evariste Galois



Experiment and share !

Special thanks to

[Daniel Estévez EA4GPZ](#)

Great open source community

And all contributors

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# Q&A



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[github.com/F5OEO](https://github.com/F5OEO)

Let's rock and contribute !

Thank you !