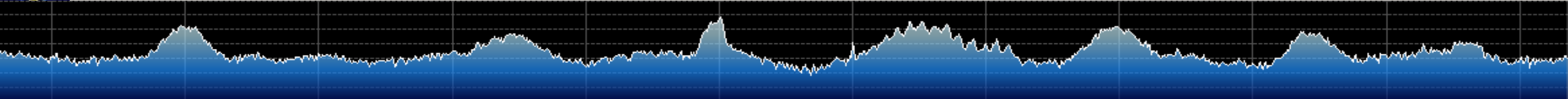# EXPLORING THE RF SPECTRUM WITH DYALOG APL
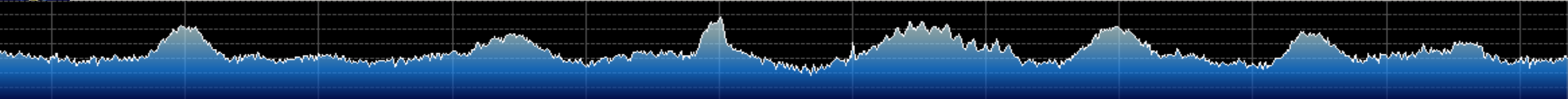
MORIS ZUCCA
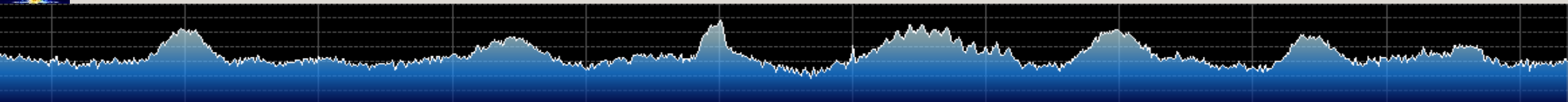
WHOAMI

- I live in Trieste where I also got my degree in Physics

- Since '08 in SimCorp Italiana (formerly APL Italiana)

- Developer on SOFIA – Software Finanziario APL

- No accounting today

CONTENTS

- A brief history of SDR

- Using an RTL device in Windows

- Connecting the RTL device with Dyalog

- Application: FM Radio

- Application: Garage opener

- Motivation & ideas

SOFTWARE DEFINED RADIO

- Implementation in software form of traditionally hardware components (modulators, demodulators, filters, up/downconverters)

- Ability to change on the fly how your «radio» works

- SDR existed for a longer time but receivers for a wide range of frequencies have been:

  - expensive

  - not portable / take a lot of space

00'S: TV ON A PC

- What we'll be using first appeared on the market as TV&Radio receiving sets for the PC

- Low cost (about 10-20 eur)

- Very small and portable

USB 2.0 TV Tuner Stick Receiver RTL2832U DVB-T SDR+DAB+FM Digital
by Amazingdeal
★★★☆☆ ▾   2 customer reviews

Price: £11.99
Sale: £8.89 & **FREE UK Delivery** on orders dispatched by Amazon over £20. Delivery Details
You Save: £3.10 (26%)

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In stock.
This item does not ship to **Italy - Mainland**. Learn more
Sold by Amazingdeal365 and Fulfilled by Amazon. Gift-wrap available.
Note: This item is eligible for **click and collect**. Details

- Digital terrestrial video and radio programs recording
- Real time digital video recording
- Still image capture
- Full DVB-T bandwidth reception

Roll over image to zoom in

RTL-SDR

- 2010 – while trying to develop linux drivers for the RTL2832U device, Eric Fry discovers raw mode is used when receiving in FM and DAB mode

- Antti Palosaari & Osmocom – development of SDR software for RTL2382U

- **R**eal**T**ek **L**abs - **S**oftware **D**efined **R**adio was born (common term for multiple designs built on the RTL2832U)
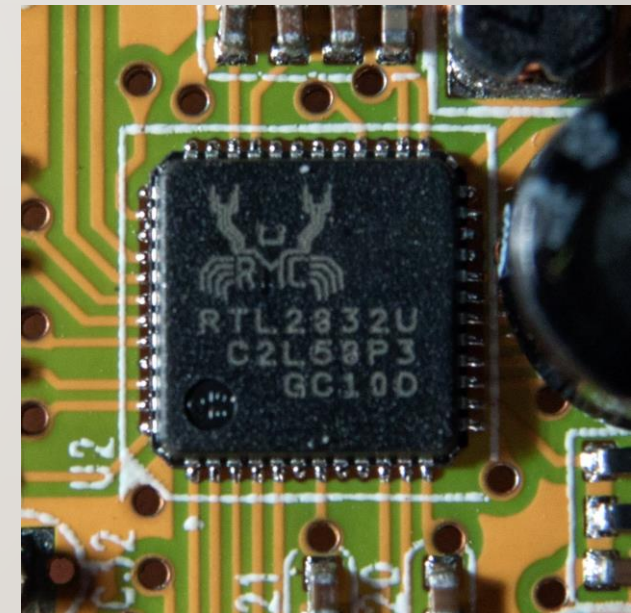
RTL-SDR / SPECS

- 3.2 M samples per sec (2.6 M stable/no signal loss)

- I/Q output, two 8 bit precision signals

- Range:
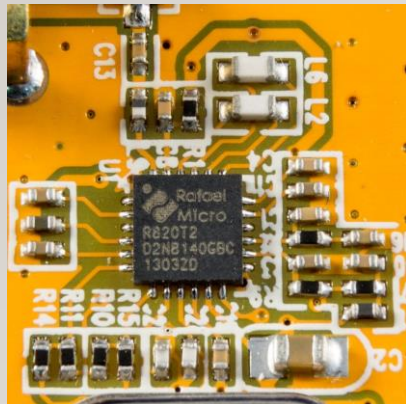
| Tuner	Frequency range
Elonics E4000	52 - 2200 MHz with a gap from 1100 MHz to 1250 MHz
Rafael Micro R820T	24 - 1766 MHz
Rafael Micro R828D	24 - 1766 MHz
Fitipower FC0013	22 - 1100 MHz
Fitipower FC0012	22 - 948.6 MHz
FCI FC2580	146 - 308 MHz, 438 - 924 MHz

USING RTL-SDR UNDER WINDOWS

- Many software (SDR#, HDSDR, GNU Radio)

- Many are based on the osmocom's open source rtlsdr dlls

- Rtlsdr libs use WinUSB windows drivers –
  use Zadig to easily switch to WinUSB from any
  driver Windows decides to use on its own

- This will be my approach as well
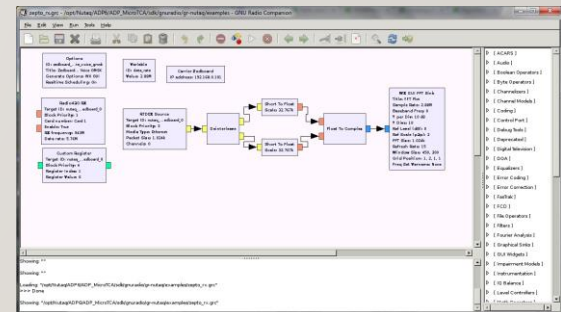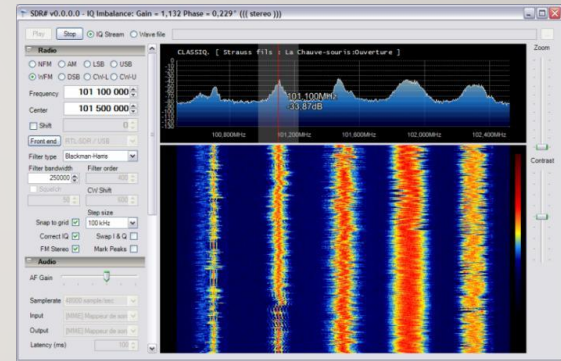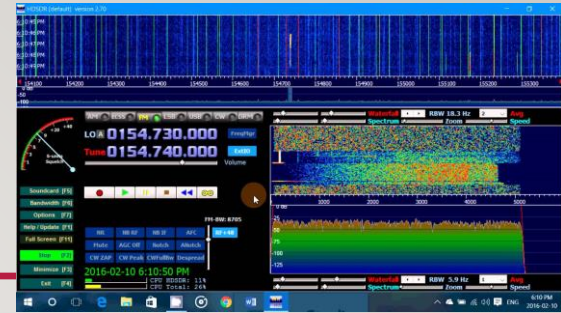
USING WITH DYALOG – HOWTO

- Download Zadig and choose «WinUSB» drivers to be used for the RTL device (careful with device choice)

- Download rtlsdr dlls (precompiled or source+compile) http://osmocom.org/projects/sdr/wiki/Rtl-sdr

- Save dlls in a system path folder

- []NAs in DyalogAPL
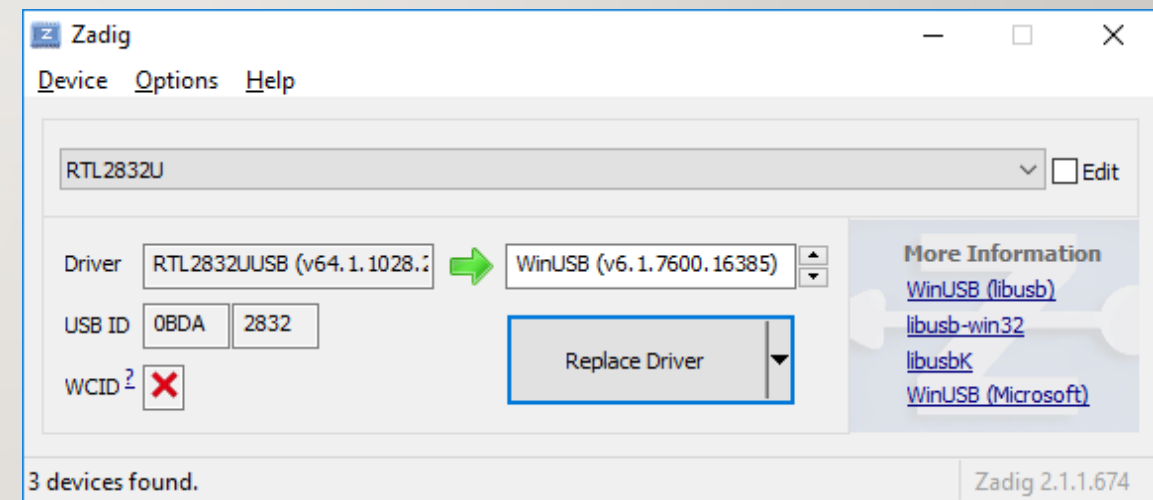
DEVICE TESTING: DEMO 1

- Name, product id, etc.

- Output: integers 8bit

- Length of output = 2 * samplerate * time (I/Q coupled samples)
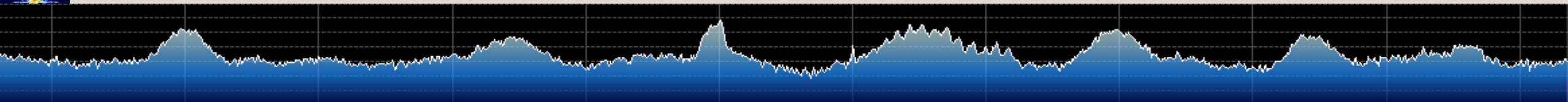
ONCE WE HAVE RAW VALUES… DEMO2

- Frequency distribution of the signal

- Signal shifting: multiply by $e^{2i\pi\frac{\Delta f}{f}}$

- Signal filtering: simplest one is $x_1' = x_o' + b*(x_1 - x_0)$

- Signal downsampling: pick each nth value of the signal, losing all high frequencies
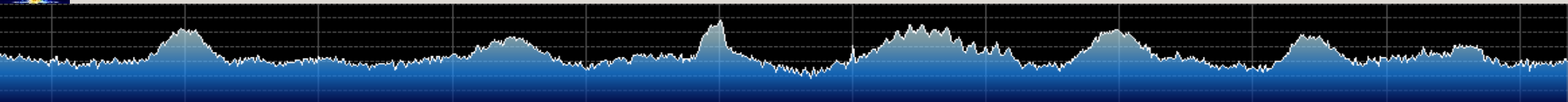
APPLICATION: FM RADIO

- The «Hello World» of SDR

- Convert I/Q signal to a complex number

- Filter and downconvert from 1MHz to ˜140kHz

- Get phase difference for each couple of values (frequency demodulation)

- Filter and downconvert again & play

- DEMO3
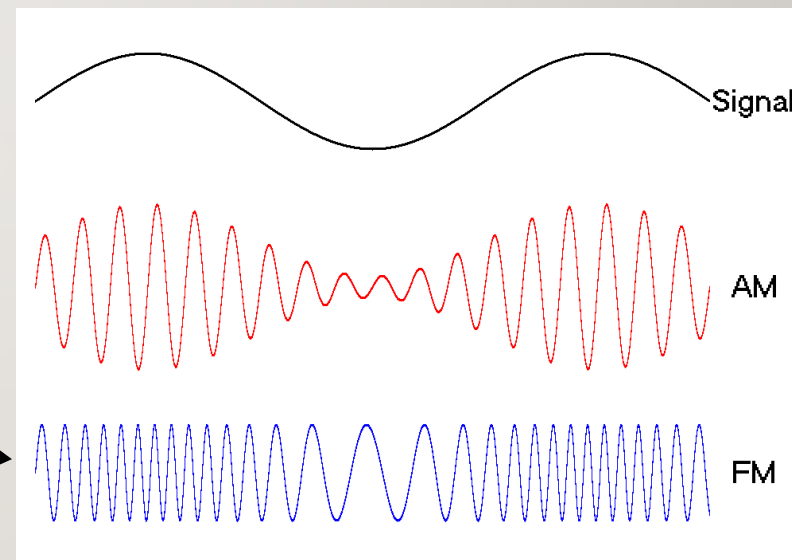
APPLICATION: GARAGE OPENER
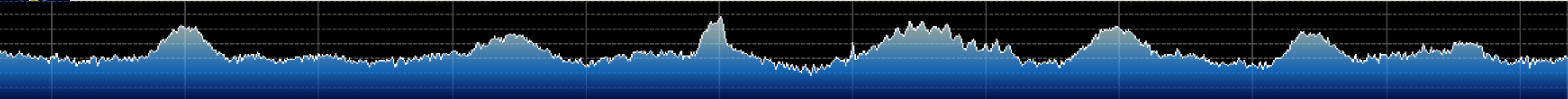
- This is my garage key: works at **868MHz**

- AM signal

- Let's see: DEMO4

A WORD ON TRANSMISSION

- Presented devices only allow receiving signals

- Other usb devices allow transmission as well

- Cost more (about 200€) but are still small and portable as well

- Stronger legal constraints

- Unlike receiving, must have a radio license

- Specific laws depend on country

OTHER IDEAS / INTERESTING SIGNALS

- NOAA satellite meteo images (APT, 137.62 MHz for NOAA-15)

- Ship tracking (AIS, 161.975 & 162.025 MHz)

- Airplane tracking (ADS-B, 1090 MHz)

- GPS satellite data (1575.42 MHz)

- RDS transmissions inside FM radio

- Debug your RaspberryPI, ZigBee, random device

- «Browse» the spectrum and identify signals (sigidwiki.com)

check rtl-sdr.com for more ideas
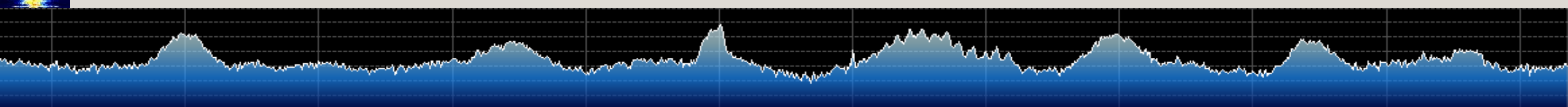
MOTIVATION

- Lots of experiments available, lots of interesting information in the RF spectrum

- Possibility to understand/modify/tweak/rewrite/test algorithms for RF filtering & decoding

- Low level understanding of RF signals while still remaining in APL

- Curiosity

- Radio was mostly a «magic box», I wanted to meet the imp living inside!

THANKS

Questions?