Introduction to Software Defined Radio (SDR)

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CVARC 4/18/13

Thanks for all the help!

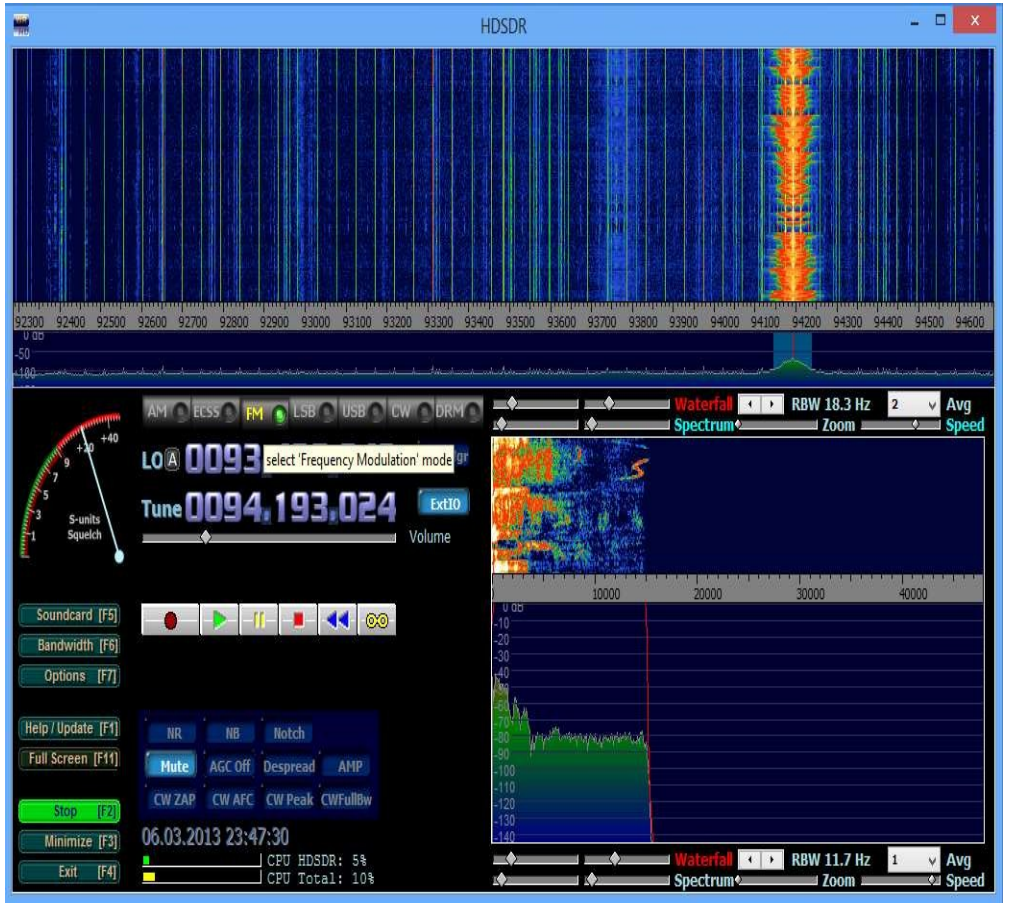
Steve Sedgwick, WB8GRS

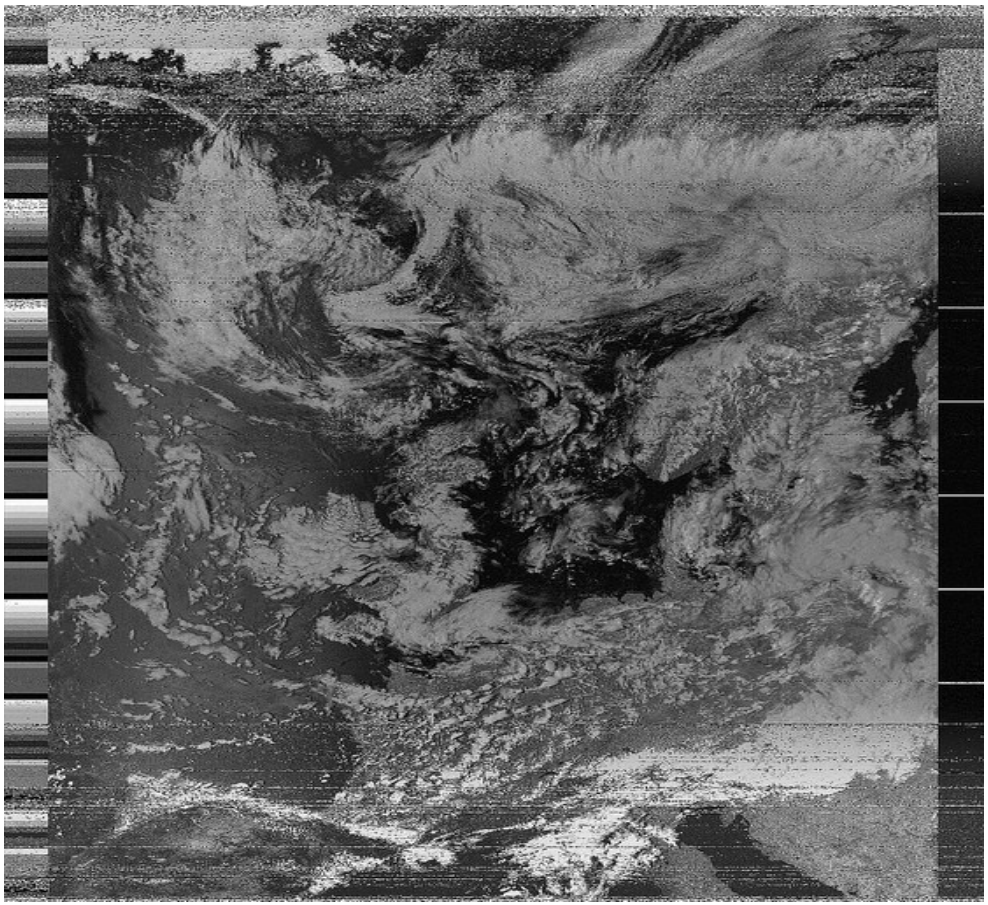
What is Software Defined Radio (SDR)

The goal of SDR is to remove all the analog parts of the radio and do it all in software.

What can SDR do for me?

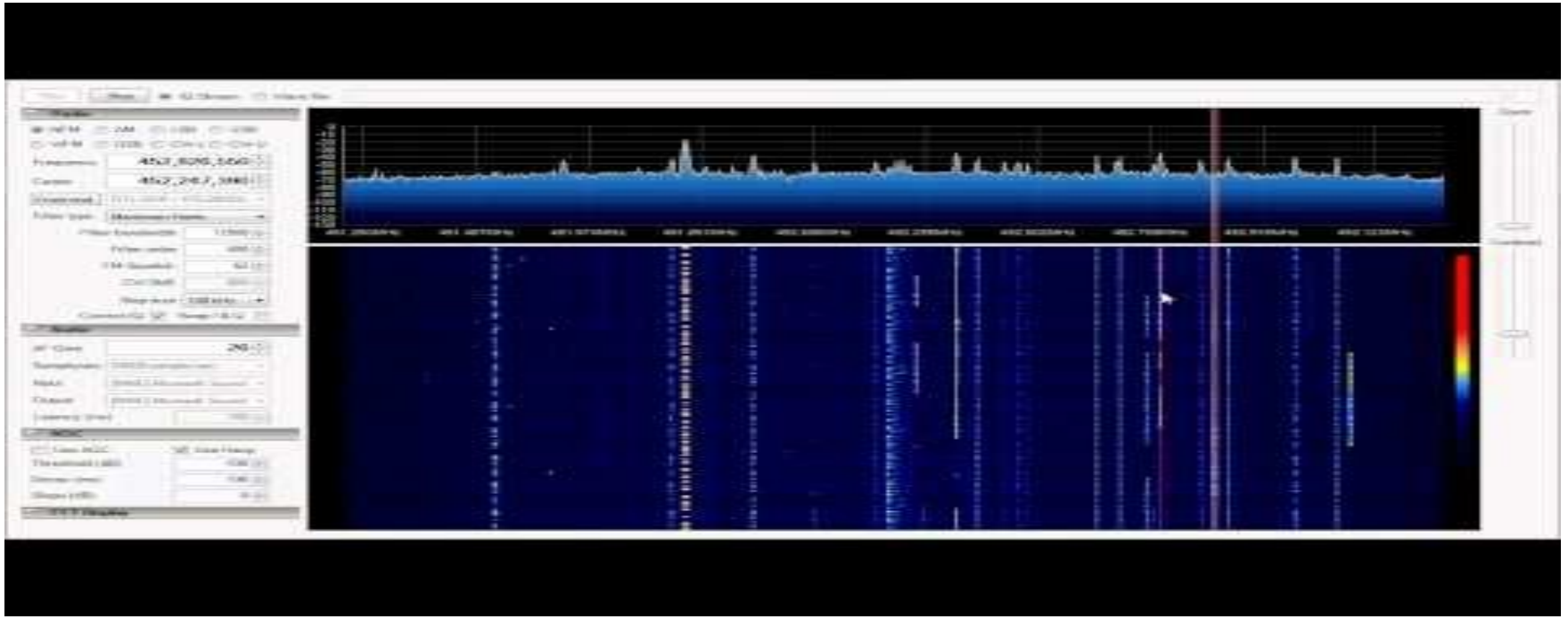
- Perform the modulation/demodulation for ALL the modes
  - NFM, WFM, AM, SSB, USB, LSB, CW, etc.
  - Work satellites with ease (auto adjustment for the Doppler effect)
    - Receive Images from weather satellites





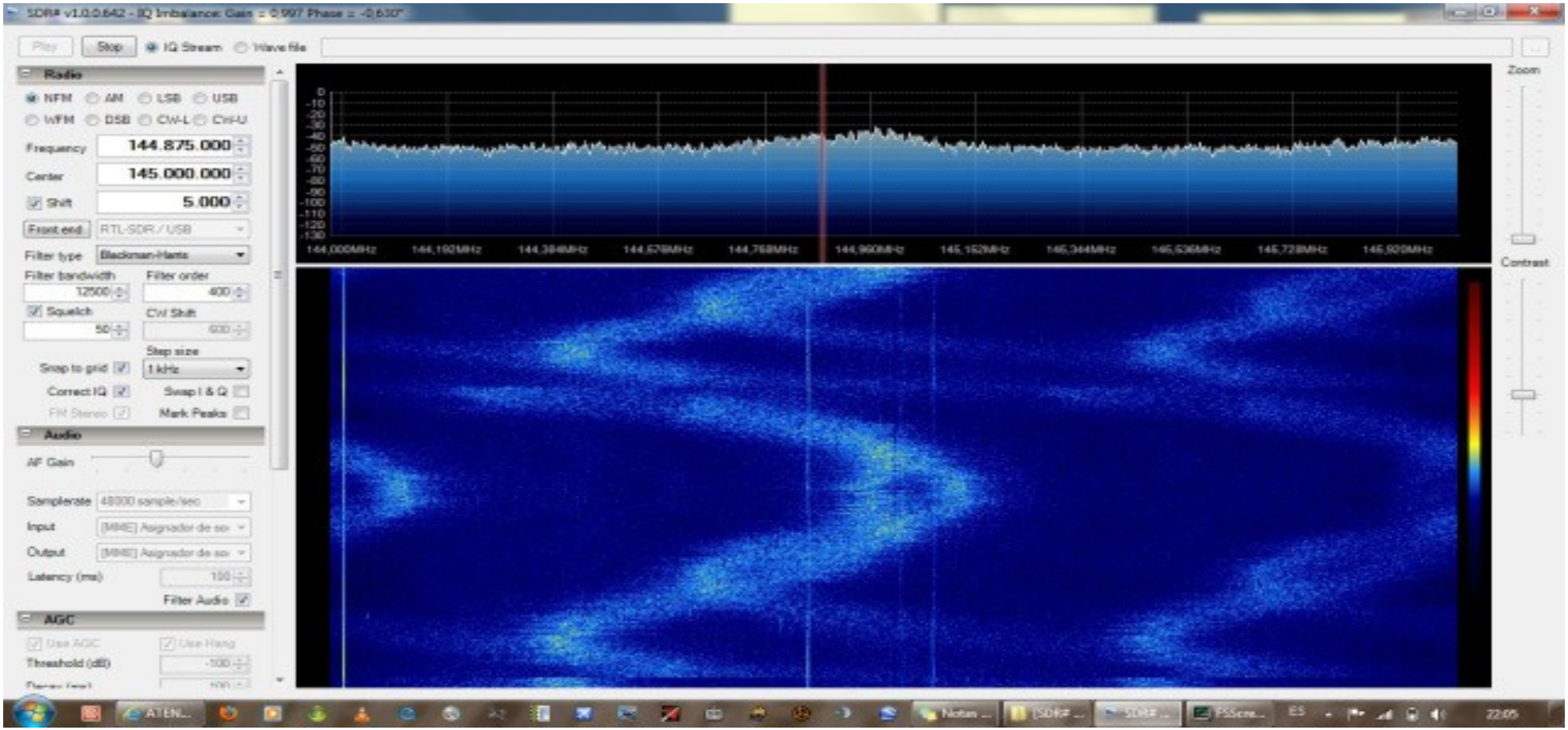
What can SDR do for me?

- Visually see a large portion of an RF spectrum.
  - See who's talking
  - Scan the bands
  - Help with contesting?



What can SDR do for me?

- Perform various RF measurements.
  - Measure signal strength, interference patterns, evaluate antennas, and many more.

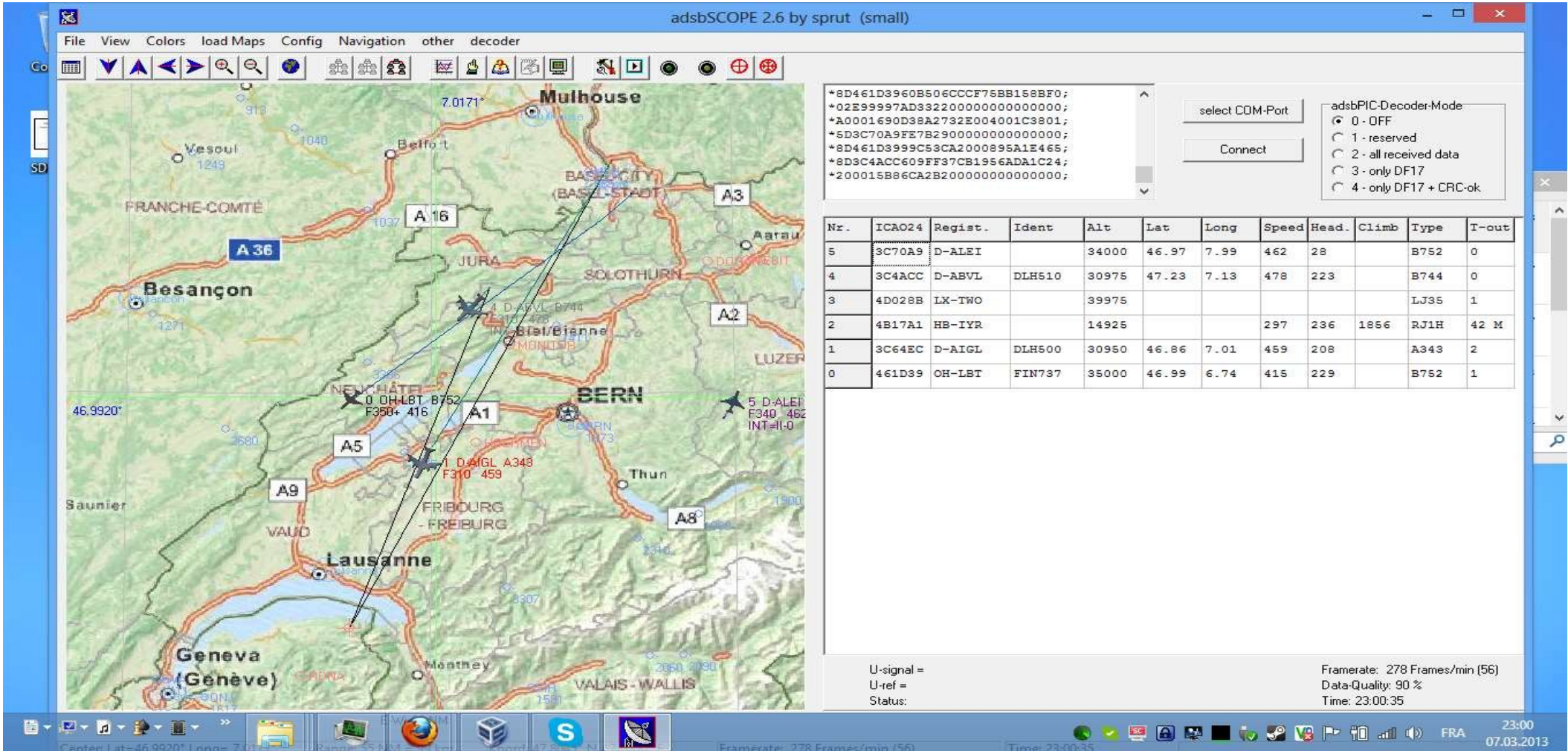


What can SDR do for me?

- Small footprint (would fit on the palm of you hand) and low cost for all of these features.

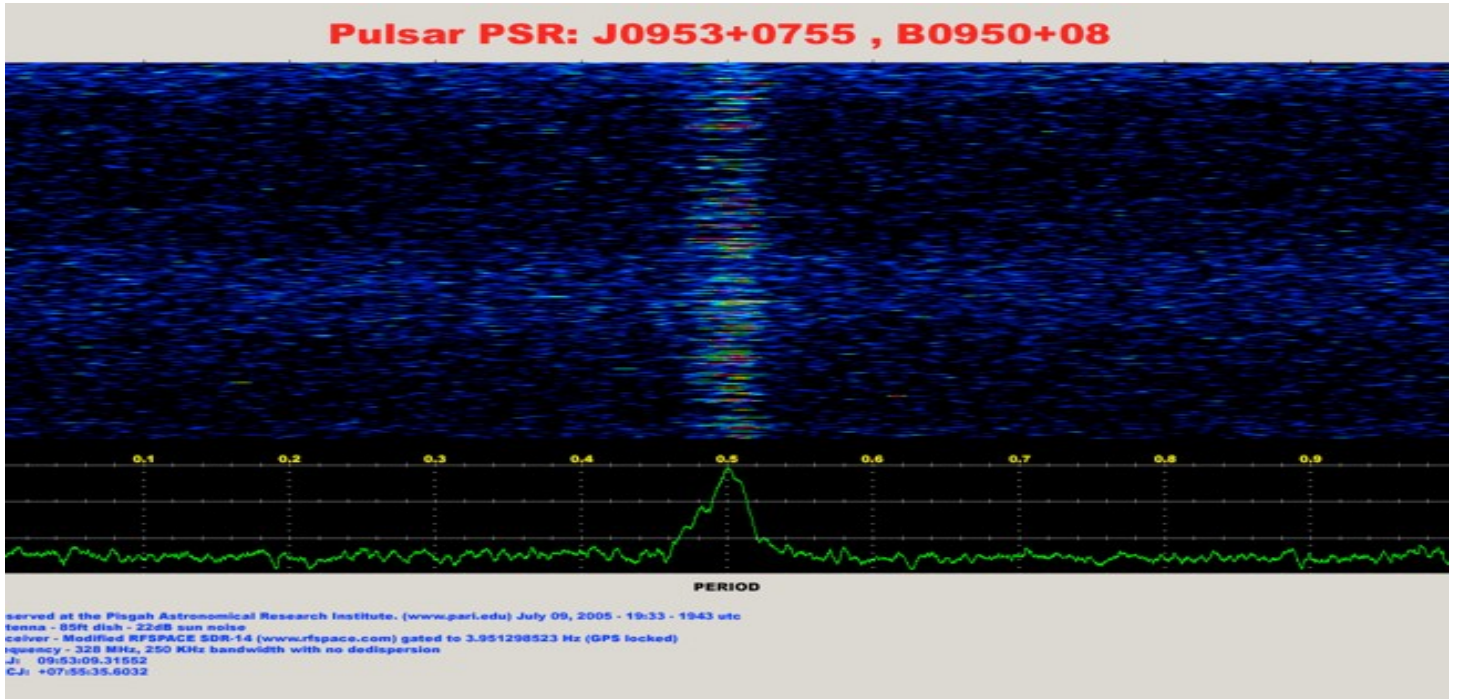
What can SDR do for me?

Plot Airplane flight paths along with weather and other sensor data using ADSB



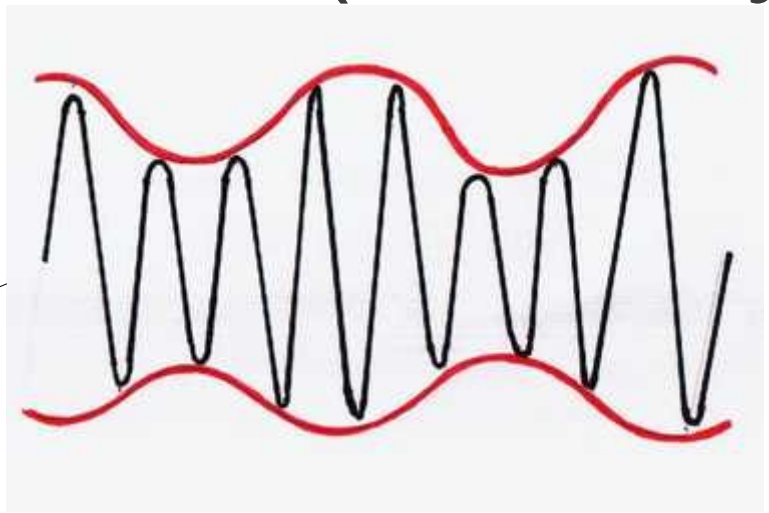
What can SDR do for me?

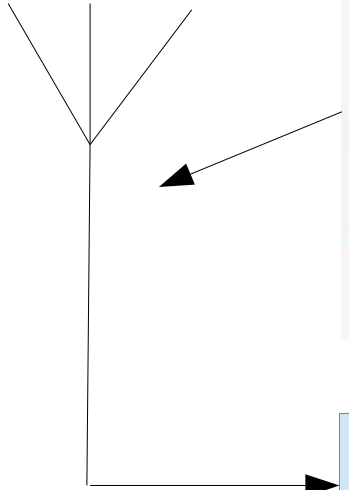
- Support any future mod/demod with just a software update.
- Can help with various experiments/advances without having to physically build circuits.
- Radio Astronomy (http://rfspace.com/RFSPACE/Astronomy.html)



How does SDR work?

How does SDR work? (in theory)

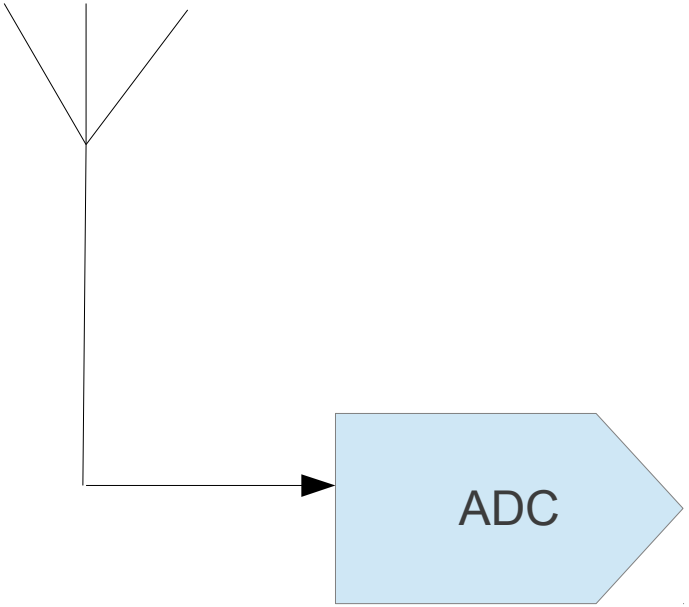




Convert the analog signals on the antenna to digital signals (0's and 1's)

Use signal processing techniques to perform filtering and demodulations.

How does SDR work? (in theory)



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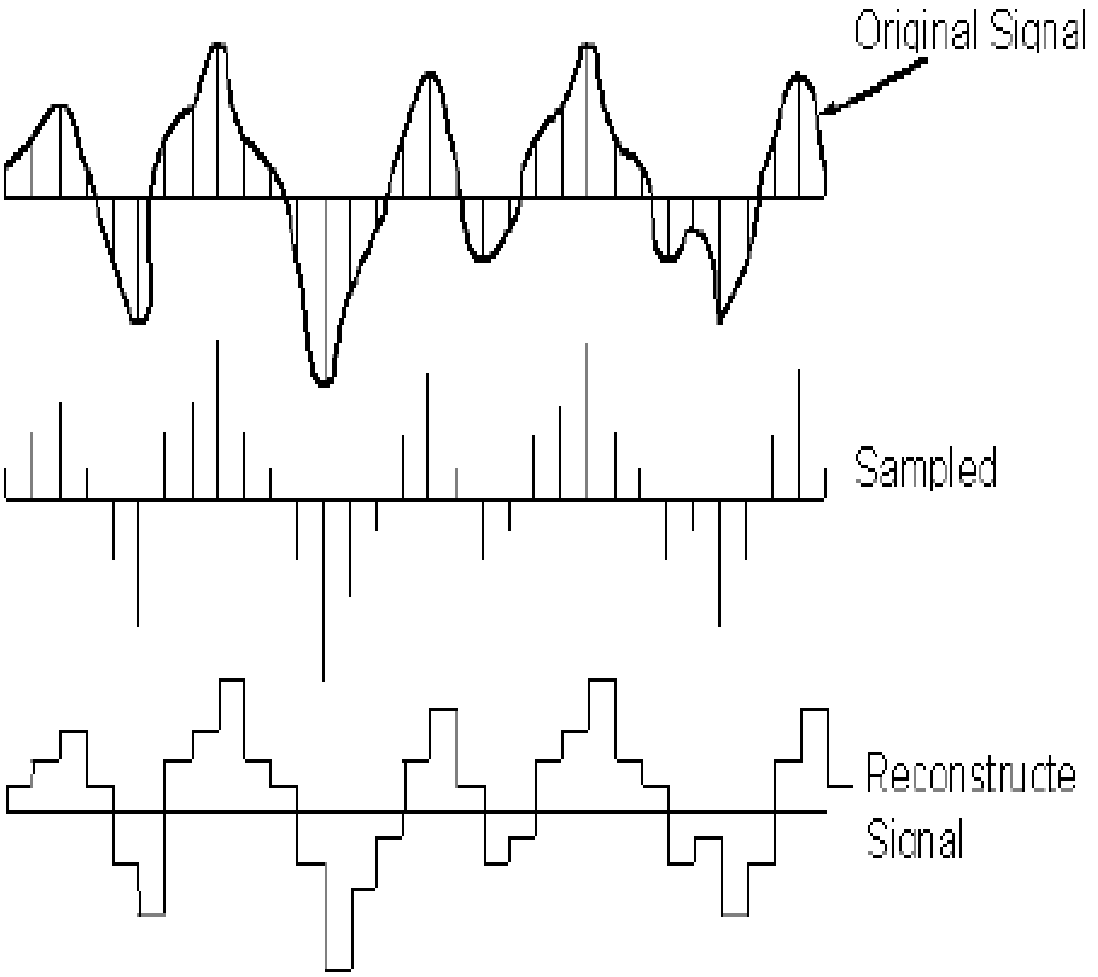
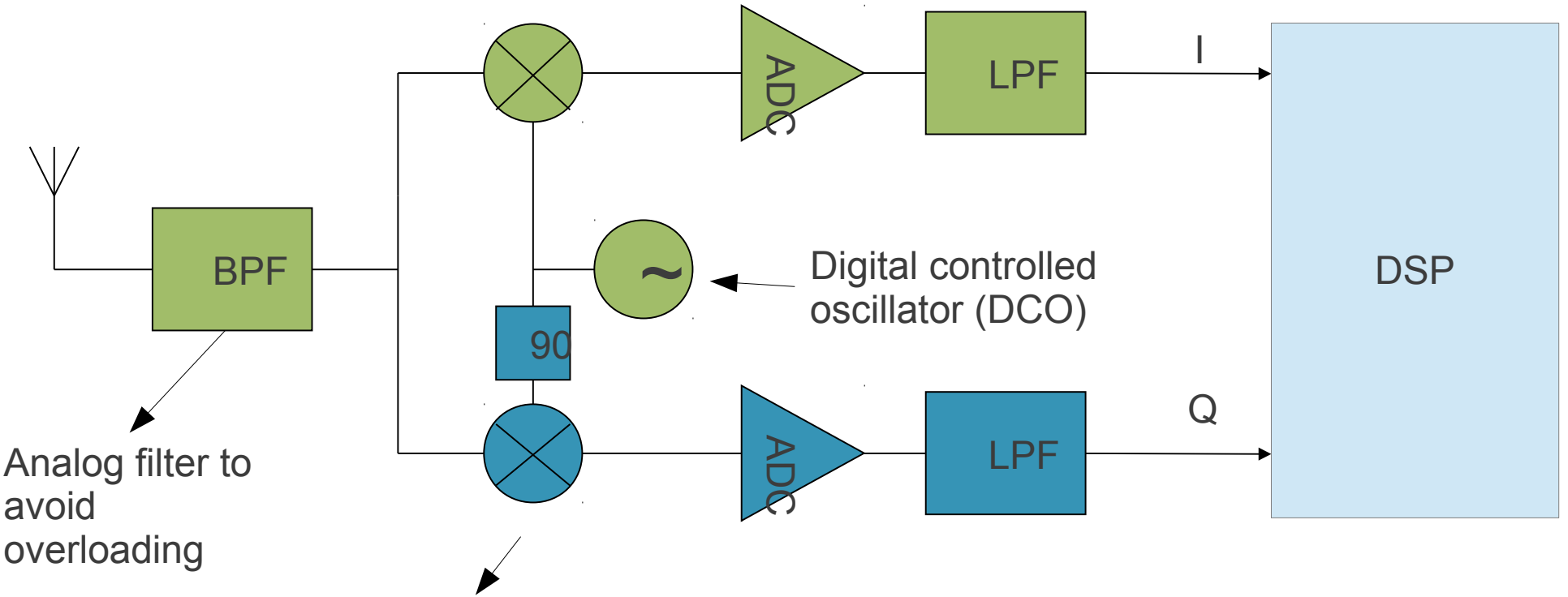


How does SDR work? (in practice)



SDR Hardware

SDR Hardware
What you need to get started

Antenna

Small piece of hardware to convert the signals from the antenna to the computer (~$18)

Computer

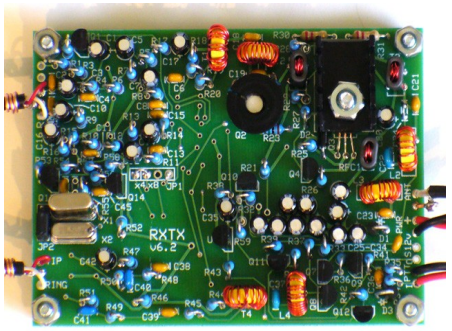
SDR Hardware

Low Cost

Use the soundcard to for ADC

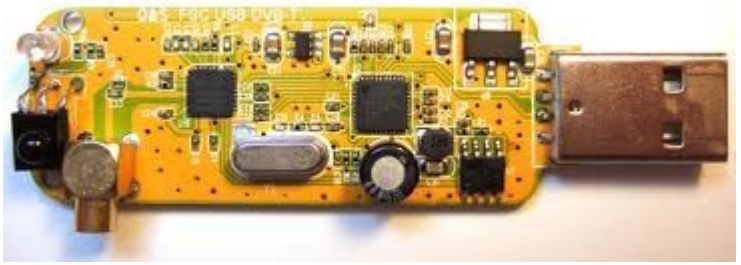
TX/RX

UHFSDR



SoftRock
Uses the Sound card for ADC

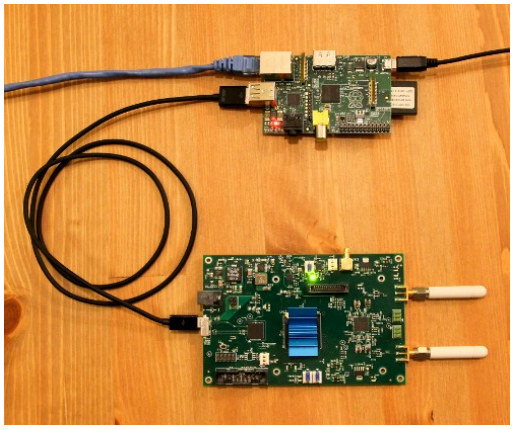
RX



SDR-RTL

Medium Cost

USRP ~$600



Blade RF ~$400

High End

FlexRadio Systems FLEX-5000A

Rhode+Schwarz $45,000

SDR Hardware
Which to choose

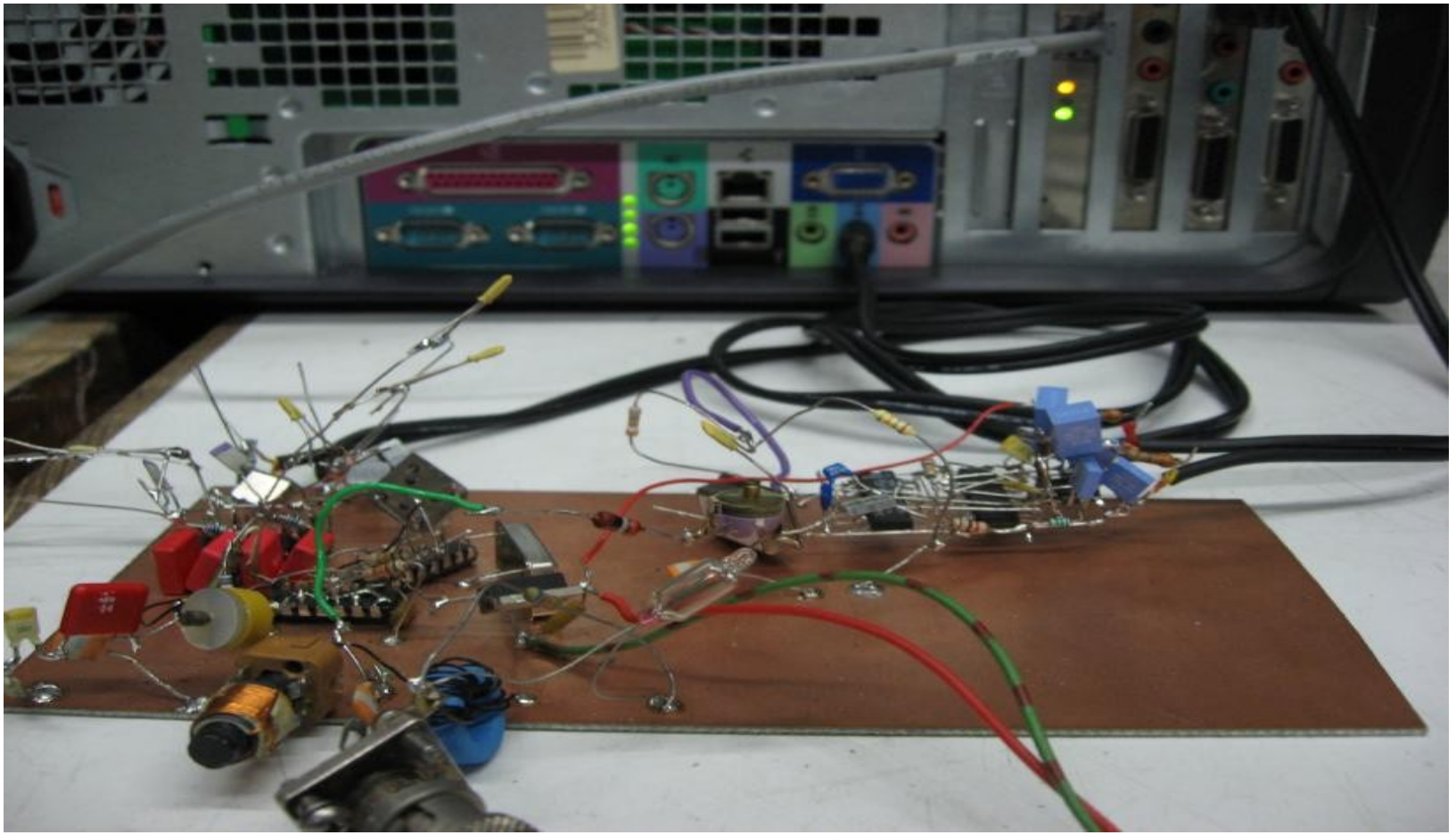
Rhode+Schwarz
$45,000

Or

RTL-SDR
$18

http://www.ebay.com/itm/Newsky-TV28T-v2-USB-DVB-T-RTL-SDR-Receiver-RTL2832U-R820T-Tuner-MCX-Input-/160896092118?pt=LH_DefaultDomain_0&hash=item25762787d6

SDR Hardware



You can always build your own...

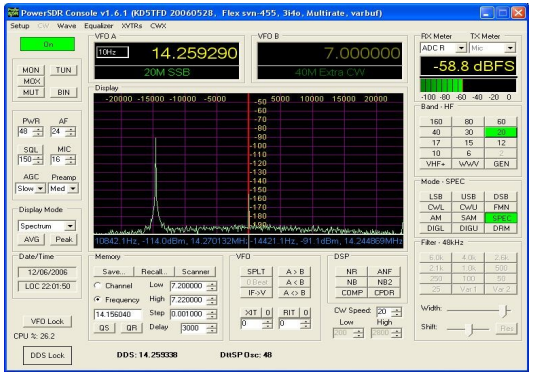
SDR Software

SDR Software

The heart of SDR.
Performs the computations for the radio part.

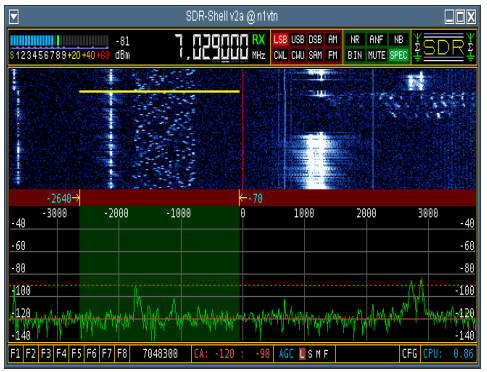
PowerSDR

http://www.flex-radio.com



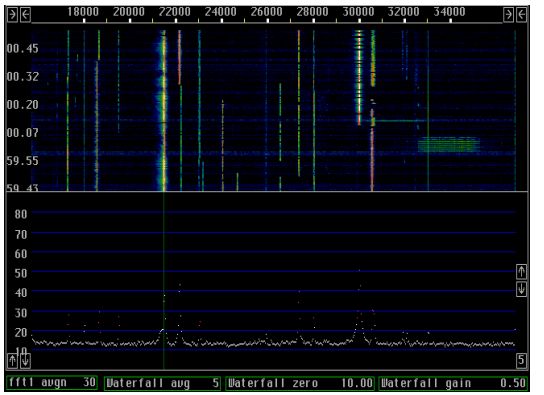
SDR Shell

http://ewpereira.info/sdr-shell



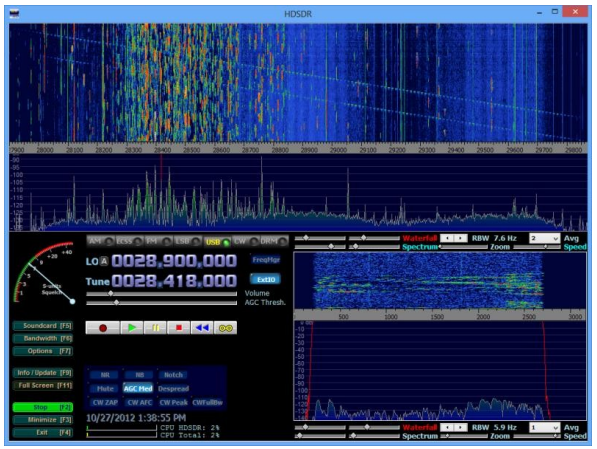
Linrad

http://www.nitehawk.com/sm5bsz/linuxdsp/linrad.htm



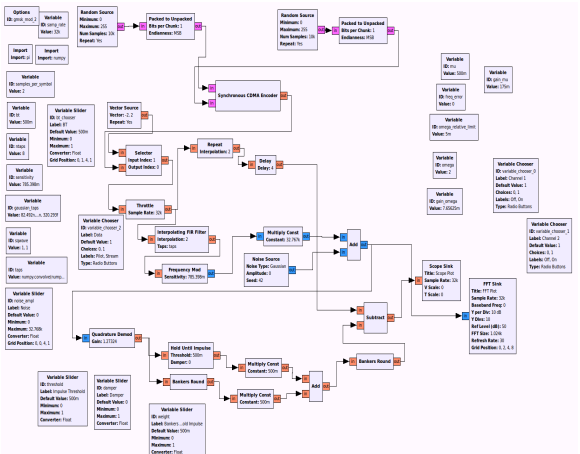
HDSDR

http://www.hdsdr.de/screenshots.html



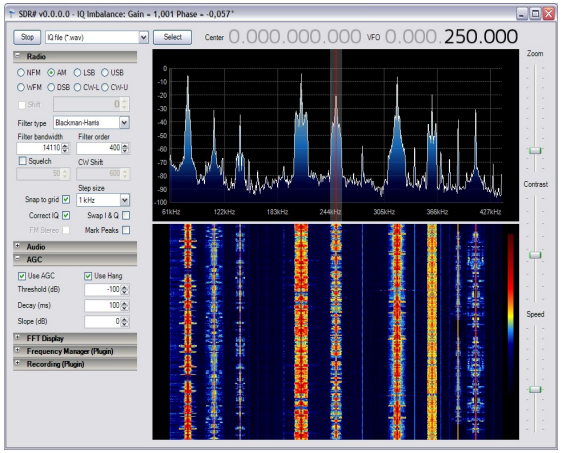
GNU Radio

http://gnuradio.org



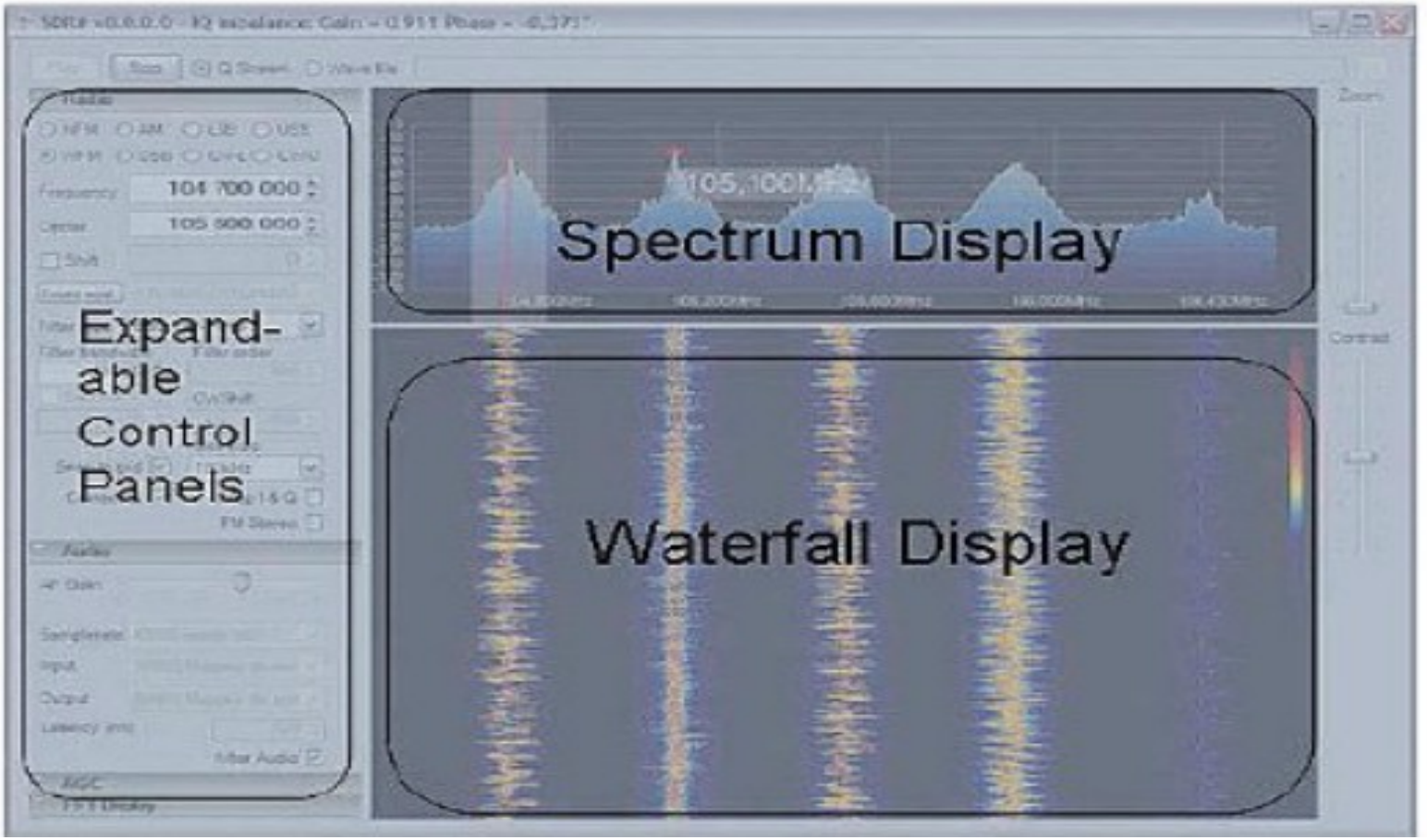
SDR Sharp

http://sdrsharp.com/



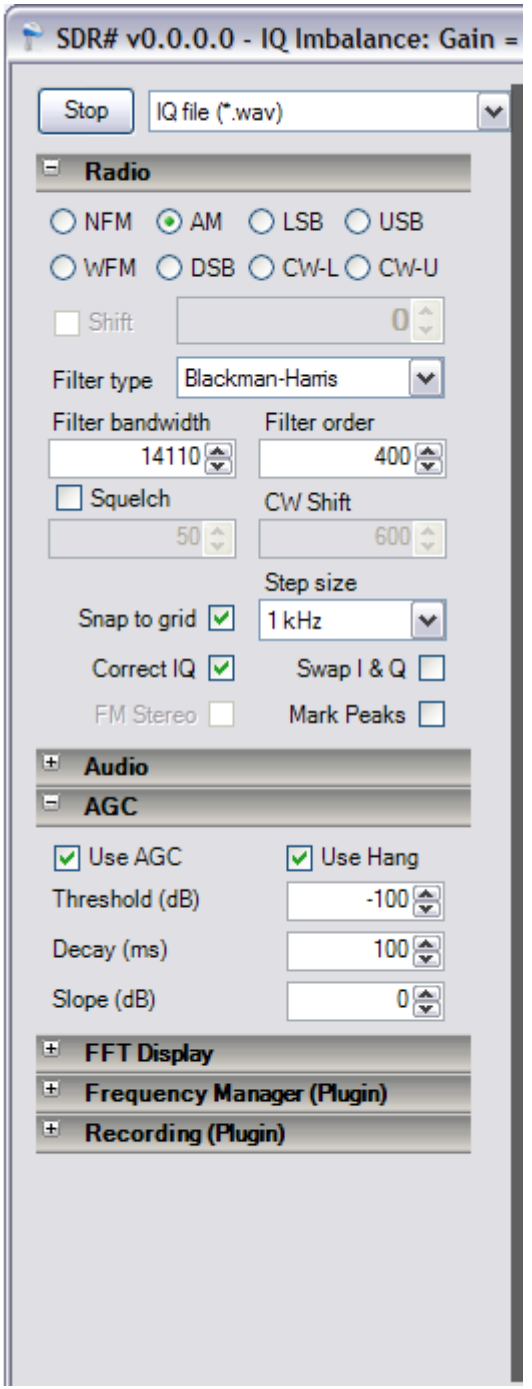
SDR Software

- All SDR software have similar GUI modules



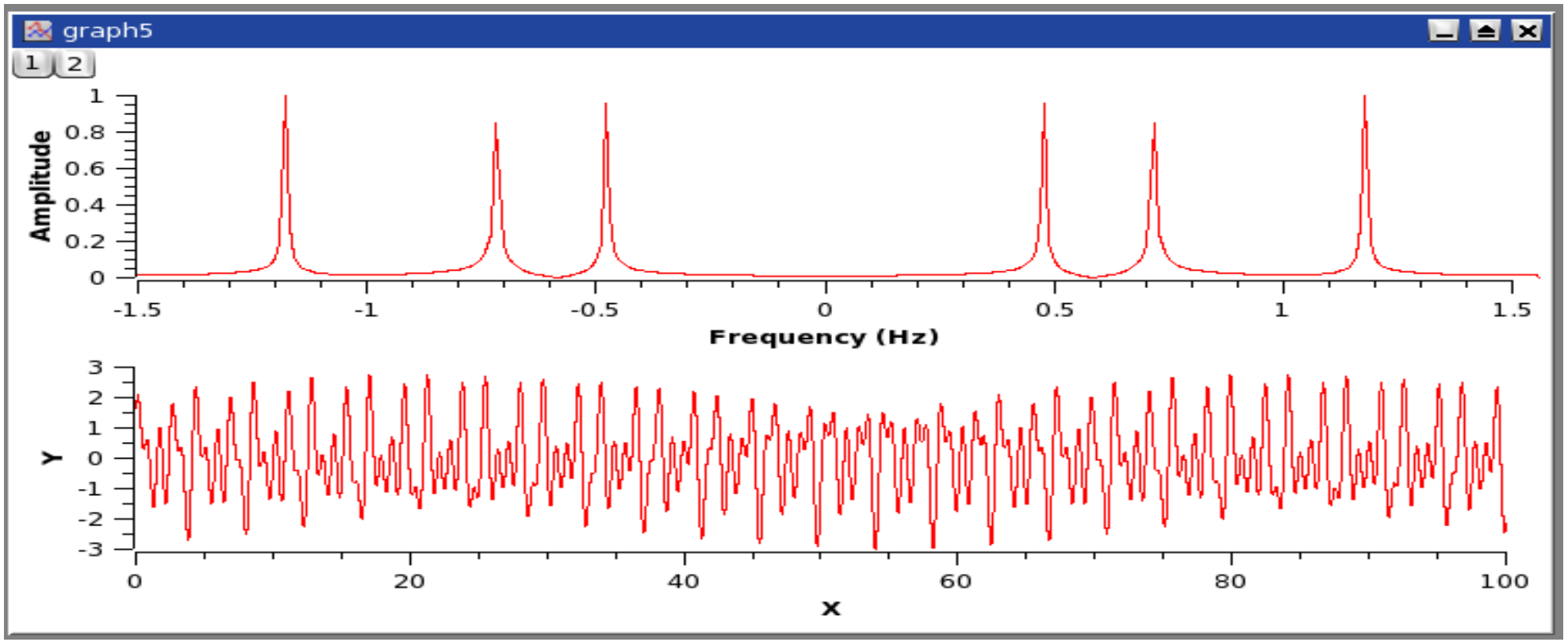
SDR Software Control panel

- Control Panel (the tuning knob)
  - Adjust the frequency
  - Change the mode (NFM, AM, CW,etc.)
  - Change filters
  - Adjust audio levels
  - Channel Memory
  - Many others depending on software



SDR Software
Fast Fourier Transform (FFT)

- Shows the frequencies present in a signal and their strength
- Converts from the time domain into the frequency domain
- Uses the Fourier theory that any signal can be broken down into individual Sine waves



SDR Software
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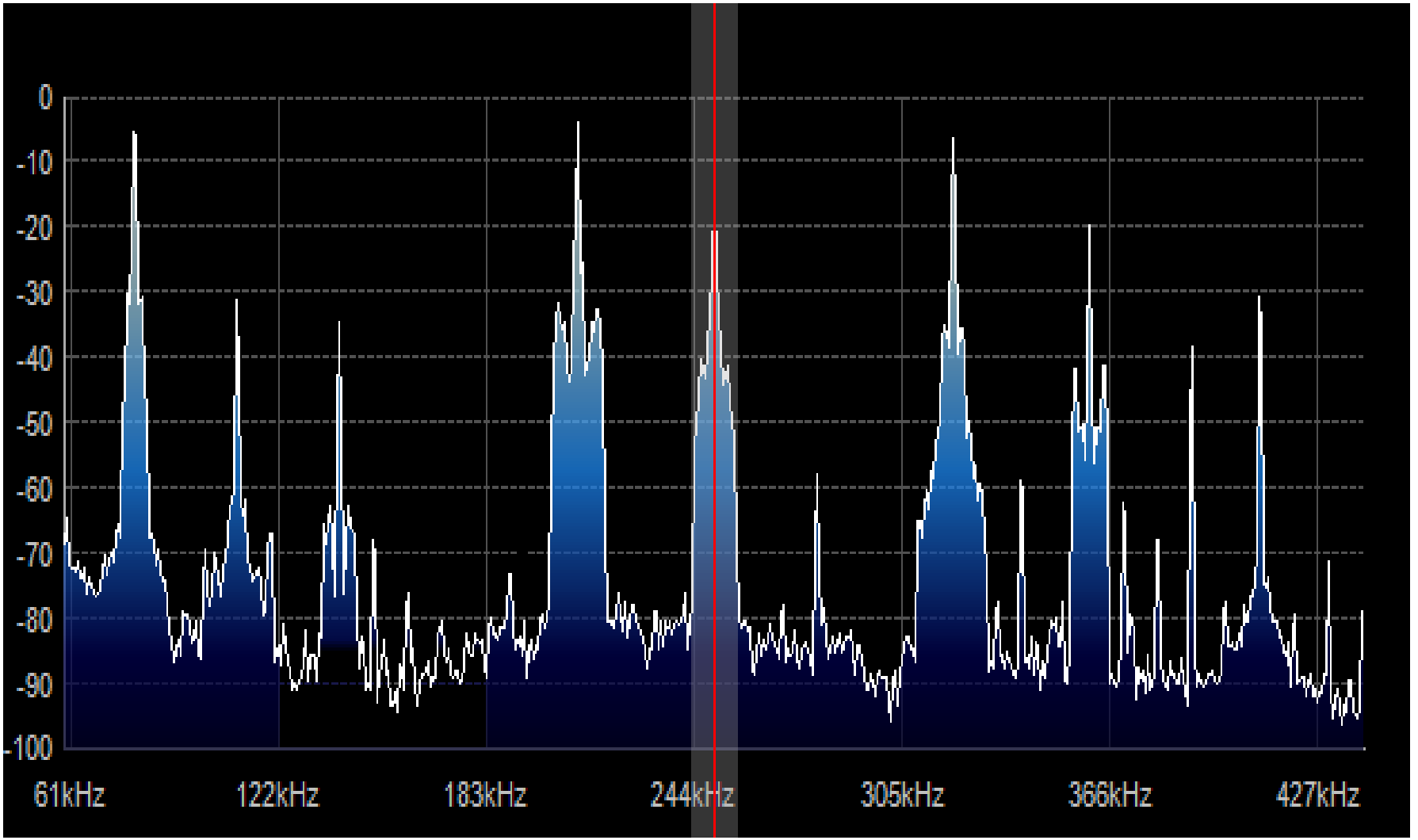
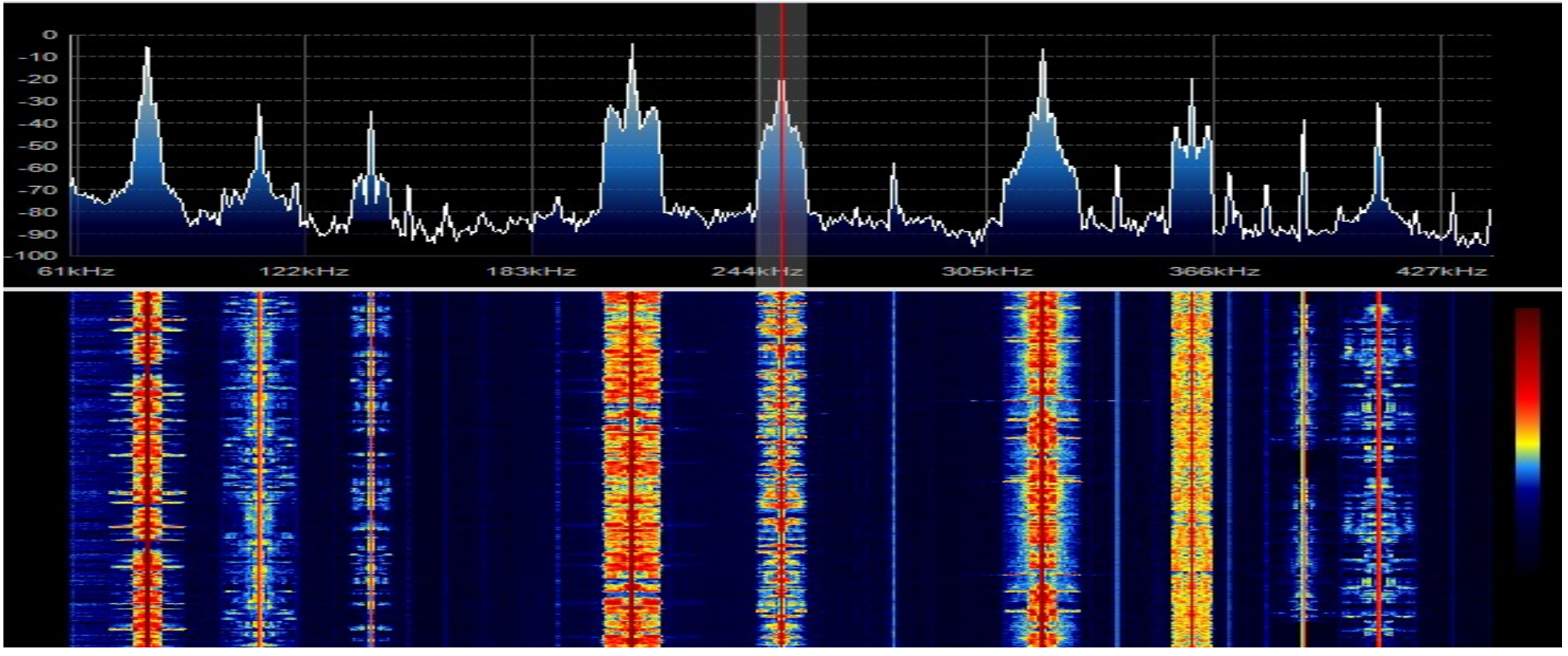


SDR Software
Waterfall (Spectrogram)

- Displays the frequencies strengths (FFT) over time
- Allows you to see signals among noise as well as identify the signals
- Color coded. Black no signal, shades from blue to red indicate stronger signals

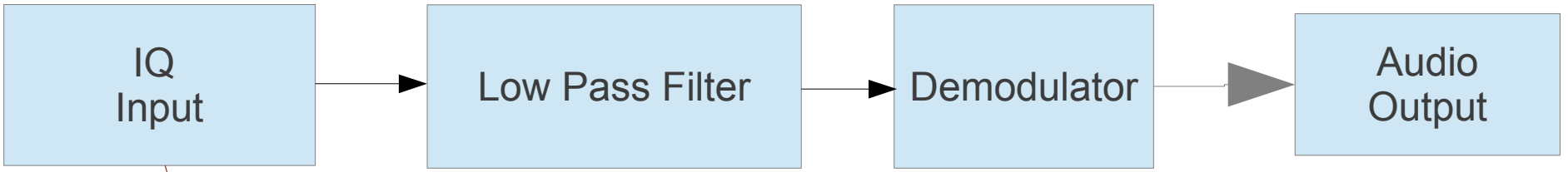


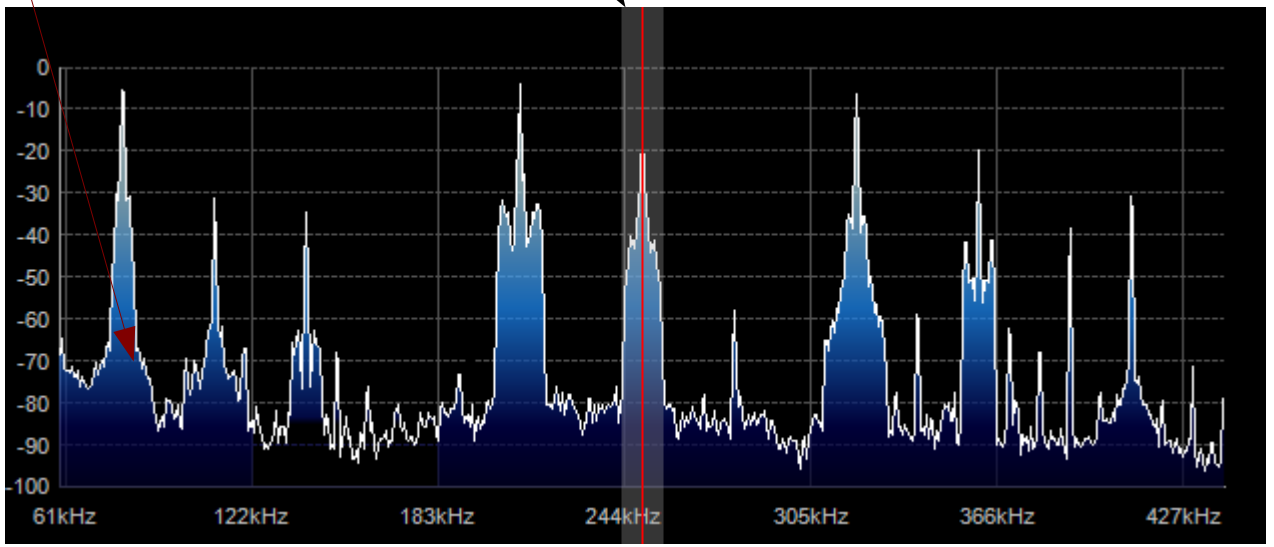
SDR Software
DSP RX simple example

The input from the ADC

Selects only the information you want

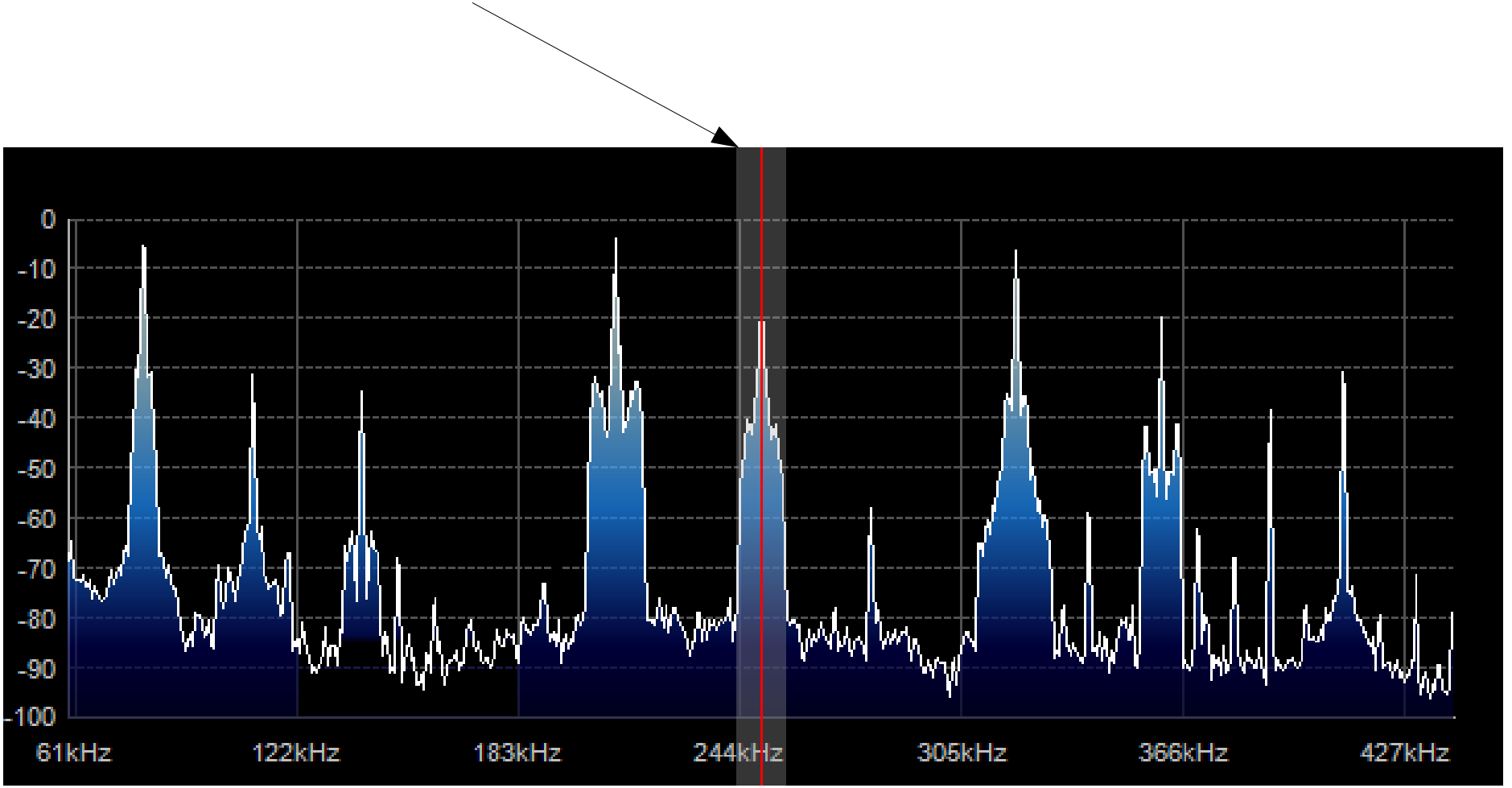
Converts from raw data to audio output



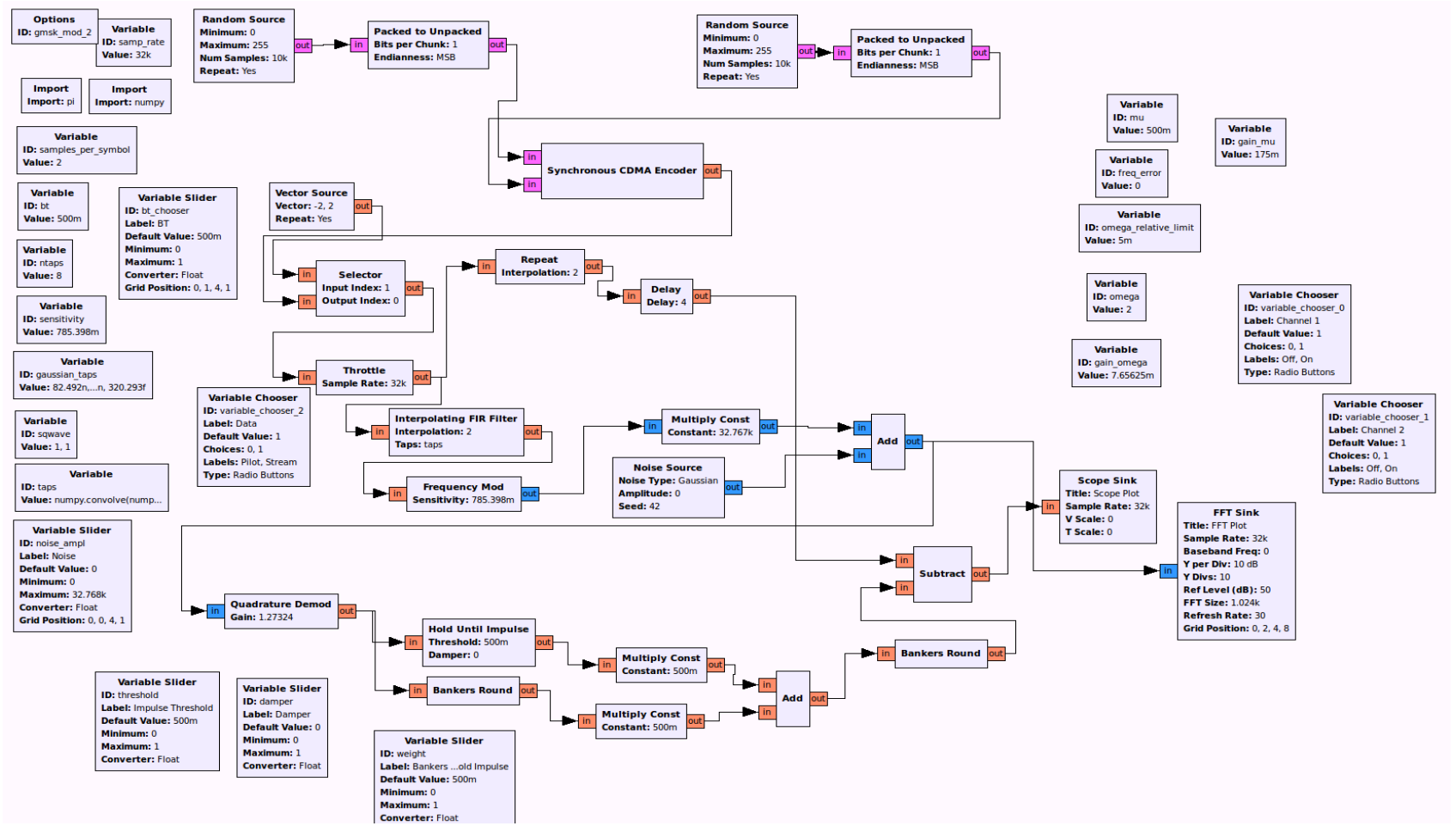


How to use the SDR Software Filters and Tuning

Filters allow us to get only the information we want



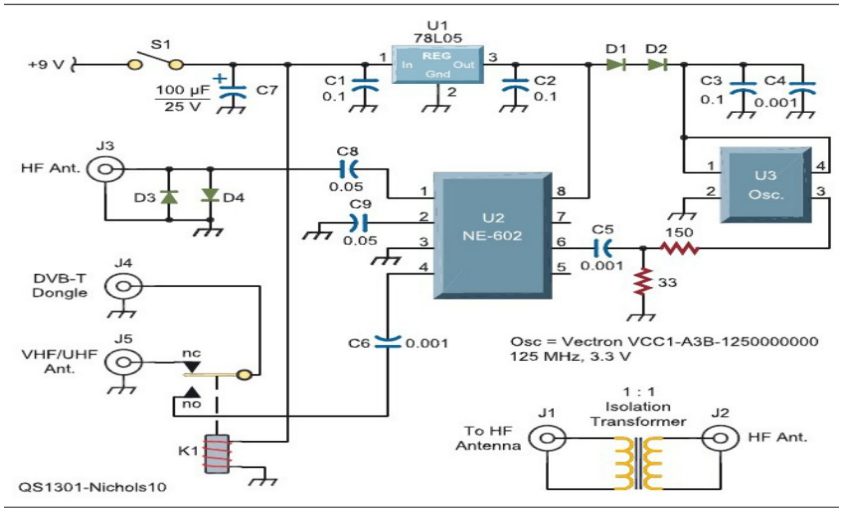
GnuRadio The Swiss army knife of SDR

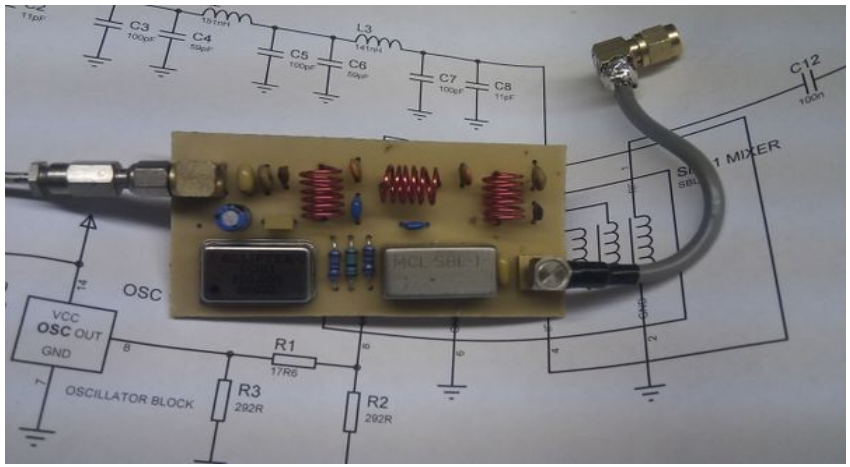


Additional RESOURCES

Listening to HF

- Need an HF upconverter
  - Basically a mixer to bring the low frequencies of HF to higher frequencies that the SDR can sample.
  - Build you own: http://www.george-smart.co.uk/wiki/FunCube_Upconverter
  - Buy from ebay: ~$40 (have never bought one)
    - http://compare.ebay.com/like/181122912430?var=lv&ltyp=AllFixedPrice



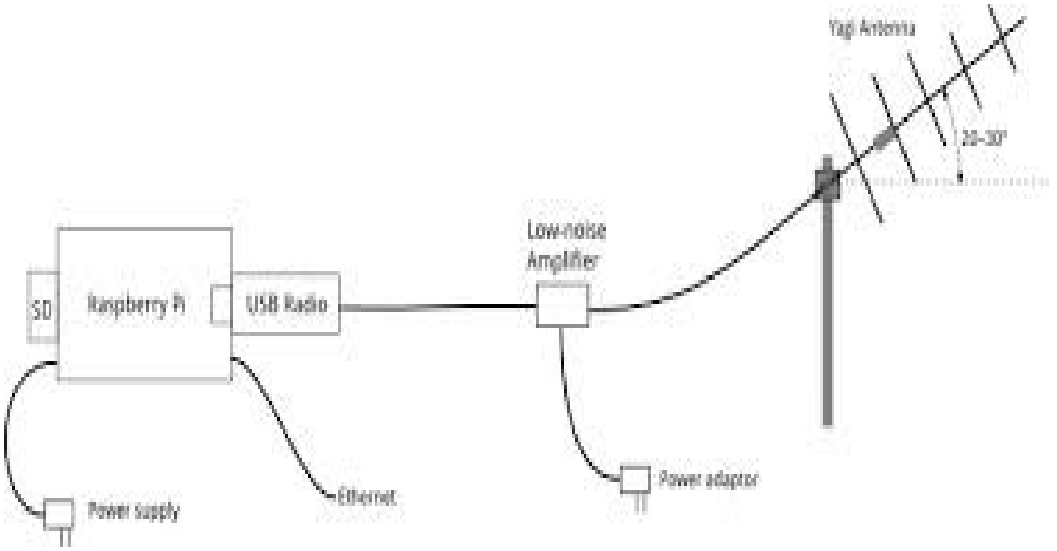


How to use the SDR Software Connecting for further processing

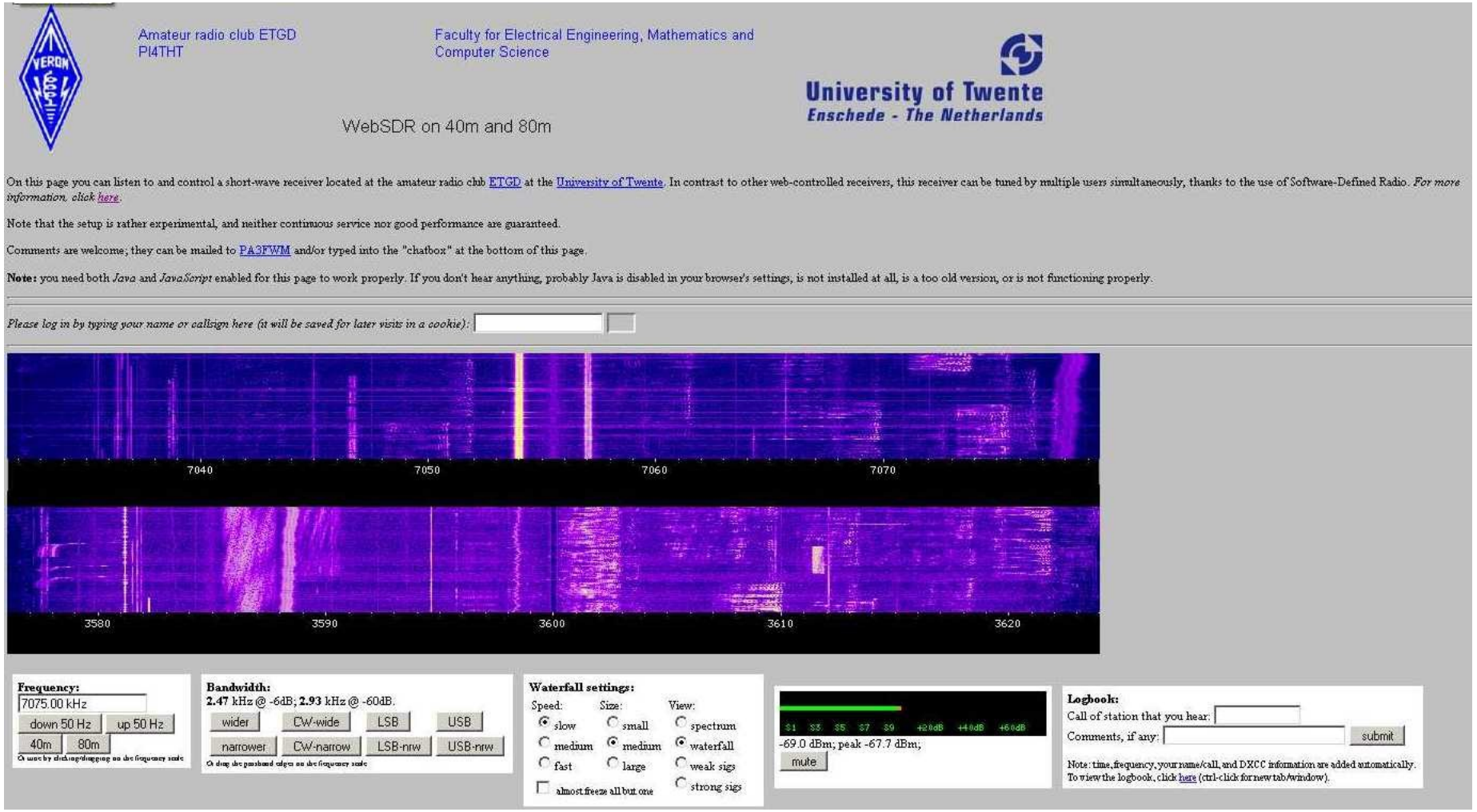
- Can connect directly to fldigi, sound-modem, or any other needed processing
- Several options available on windows
  - Choose the mixer input or microphone input
    - Change settings in SDR# under the audio section.
  - Install virtual audio cable ($25)
    - http://software.muzychenko.net/eng/vac.htm
  - Install jack audio (free, but Good luck)
    - http://jackaudio.org/
  - Connect a cable from line out to the line in of the computer.
    - Use the mic as input
- On linux simply use pipes or FIFO
- Mac????

Remote ADC
avoid feedline loss

- Place the ADC right next to the antenna
  - Raspberry pi with TCP connection
    - http://zr6aic.blogspot.com/2013/02/setting-up-my-raspberry-pi-as-sdr-server.html



Web SDR



http://websdr.ewi.utwente.nl:8901/

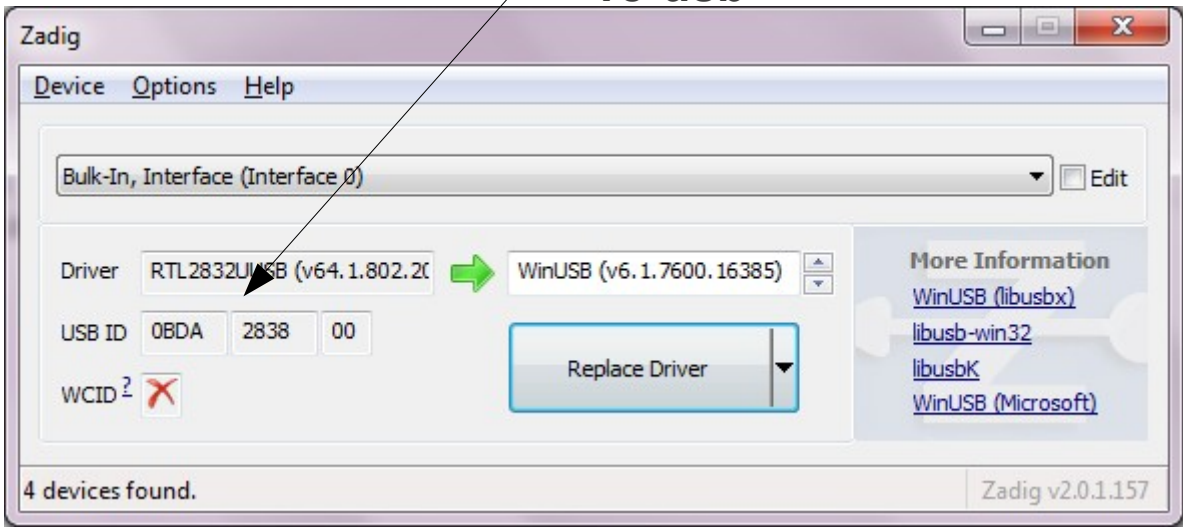
Getting started
How To

- Buy the USB dongle:
  http://www.ebay.com/itm/Newsky-TV28T-v2-USB-DVB-T-RTL-SDR-Receiver-RTL2832U-R820T-Tuner-MCX-Input-/160896092118?pt=LH

  Cut the antenna and place a pl259 UHF connector

- Install SDR Sharp:
  http://rtlsdr.org/softwarewindows
  - Install the drivers: use Zadig
  - Install SDR# sdr-install.zip
- Tune ppm so the freq will display correctly
  - In SDR# click configure

Check ID aginst http://rtlsdr.org/hardware-usb



Performance Tips

- Antenna is everything!
- Eliminate feedline losses by mounting the SDR at the antenna feedpoint, with weatherproofing and a long USB cable to the computer or Ethernet though the raspberry pi.
- Use a bandpass filter to protect the radio from strong out-of-band signals.
- Consider a quality preamplifier for the RTL-SDR to reduce the system noise figure.
- Reduce the SDR's internal gain to prevent noise due to RF clipping and intermodulation
- Enclose the device in a grounded metal case.
- Filter the +5V supply to the radio. Use a combination of ferrite beads and bypass capacitors to target the full spectrum of noise.
- Put RF Chokes on the USB cable to filter out computer noise.
- Software tricks, such as oversampling and decimation can help - watch for RTL2832 firmware and driver updates!

References

- http://www.ab9il.net/software-defined-radio/rtl2832-sdr.html
- http://www.hamsdr.com/StartHere.htm
- http://www.hamsdr.com/WA2DFI/Hands_On_SDR_%20Dayton_2008_v0_9.ppt
- http://wb5rvz.com/sdr/
- http://sdrsharp.com/
- http://www.baycom.org/~tom/ham/soundmodem/
- http://www.insomnihack.ch/images/insomnihack-mar13-bk-sdr.pdf#page=10&zoom=auto,0,458
- http://www.pe0sat.vgnet.nl/tag/sdrsharp/
- http://2600.wrepp.com/2600/Links/29/3/superkuh.com/gnuradio.html
- http://wb6dhw.com/For_Sale.html#UHFSDR
- http://www.davegardner.org/Ham/PDF/EasySDR.pdf
- http://zr6aic.blogspot.com/2013/02/setting-up-my-raspberry-pi-as-sdr-server.html
- http://www.oz9aec.net/index.php/gnu-radio/gnu-radio-blog/477-noaa-apt-reception-with-gqrx-and-rtlsdr
- http://www.arrl.org/files/file/Technology/tis/info/pdf/020708qex013.pdf
- http://v2.sdr-radio.com/Download.aspx

Live Demo...
And Questions.