SOFTWARE DEFINED RADIO RECEPTION: ON THE CHEAP!

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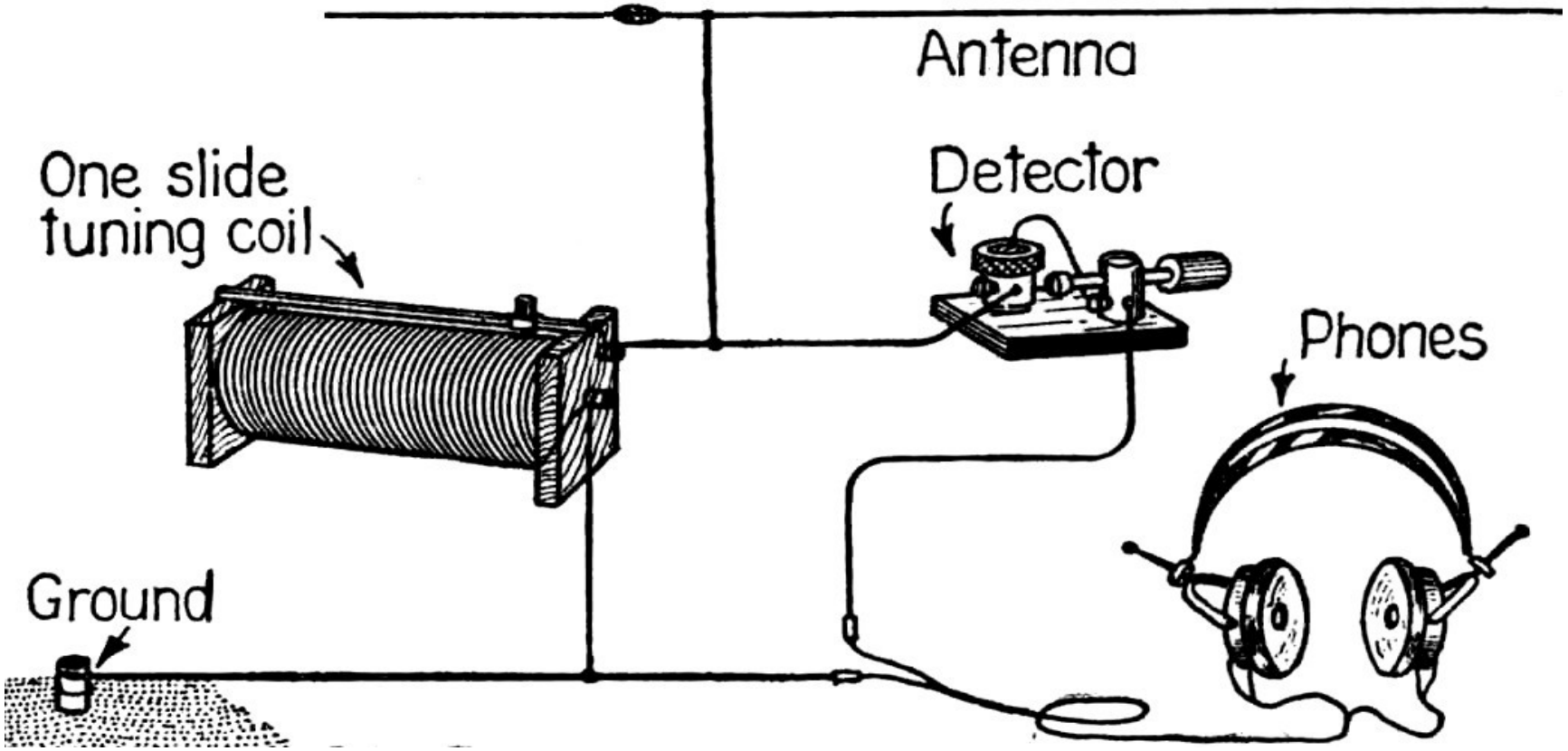
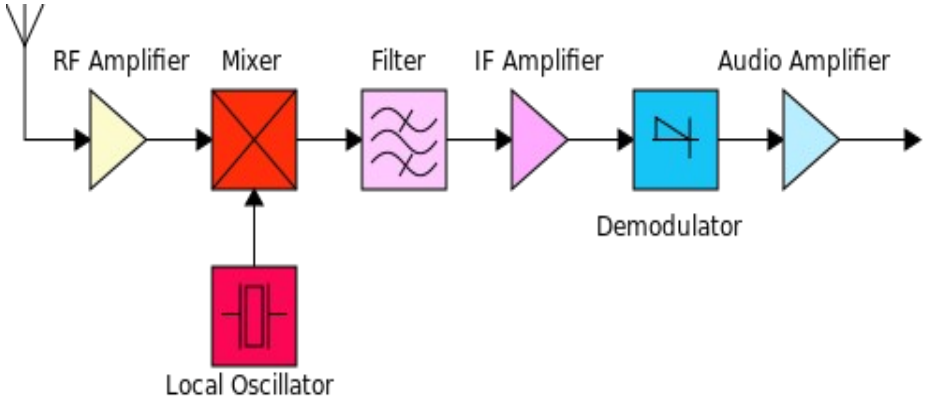
Review of Traditional Analog Rx: *The Crystal Set*



Source: http://en.wikipedia.org/wiki/Crystal_radio

SuperHet to the Rescue



Superhet circuit improved simple analog by...

- Adding radio frequency (RF) amplifier (pre-selector)
- Signal is then fed into a circuit where it is mixed with a sine wave from a variable frequency oscillator known as the local oscillator (LO)

- output of the mixer may include the original RF signal at f_{RF}, the local oscillator signal at f_{LO}, and the two new heterodyne frequencies $f_{RF} + f_{LO}$ and $f_{RF} - f_{LO}$.
- There *will* be many mixer products (heterodynes)
- The IF stage includes a filter in order to achieve the desired selectivity
- IF amplifier is tuned to a fixed frequency and is selective around its center frequency f_{IF}.
- Received signal is processed by the demodulator stage where the audio signal is recovered and then further amplified.

Source:
http://en.wikipedia.org/wiki/Superheterodyne_receiver

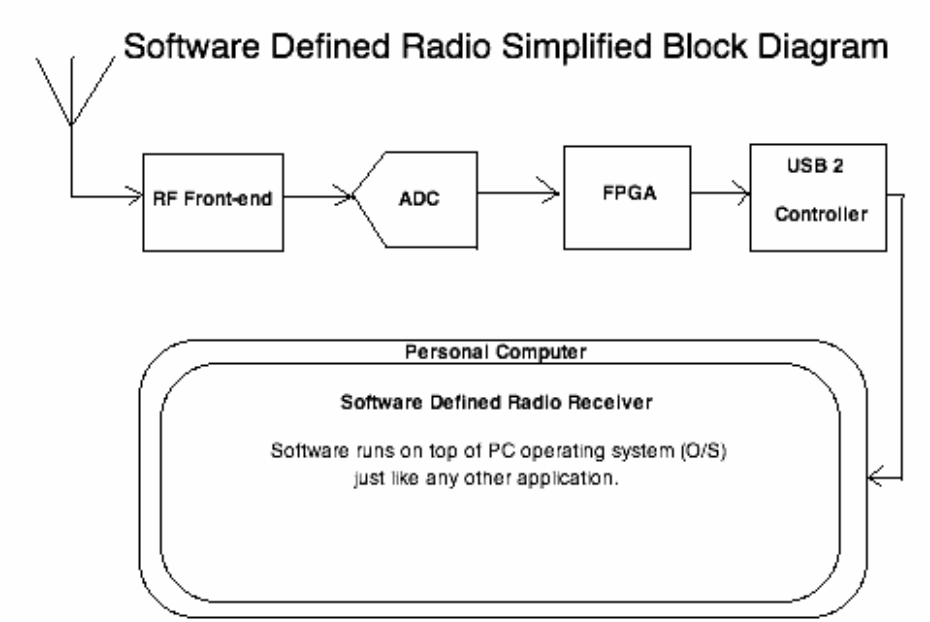
Superhet: Problems

- **Image frequency** (f_{img}): an undesired input frequency = the station frequency plus 2x the IF, resulting in 2 stations being received simultaneously
- **Local oscillator radiation**: Rx's LO can act like a low-power transmitter, mutual interference to nearby Rx
- **Local oscillator sideband noise**: LOs have random phase modulation, causing a widening of the Rx's frequency response, defeating the aim to make a very narrow bandwidth Rx

SDR's Approach

- Software “Defined” Radio vs. Software “Controlled” Radio
- Using a PC to control a Rx (or transceiver) by changing bands, frequencies, volume, etc. is NOT SDR. (Advertising by products like Ham Radio Deluxe might suggest it is...but not so.)
- SDR is an evolving concept as most innovations experience but “defined” radio by software at minimum involves how the signal is treated at the IF block.

Simplified SDR Block Diagram



- First, as with any other radio receiver, the antenna is connected to the SDR's "hardware" RF front-end. Its purpose is to..
  - Interface physically with the antenna for optimum RF energy transfer to the receiver.
  - Serve as low-pass or band-pass filter
  - Amplify the signals.
  - Convert the frequency of signals down to an intermediate frequency (IF) suitable for the ADC stage that follows.
- The departure from a conventional receiver starts here.

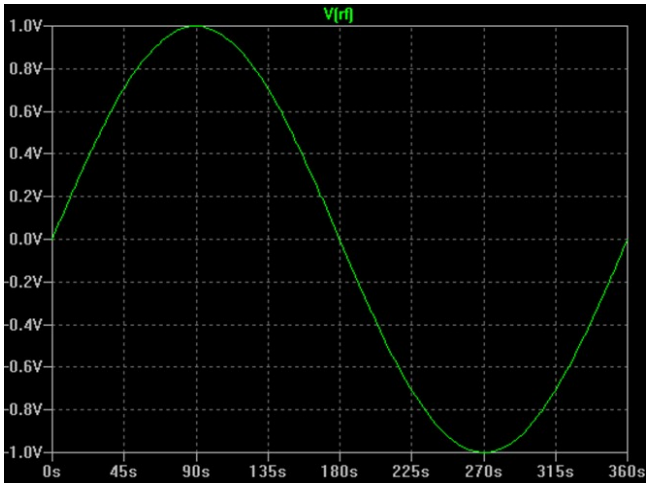
- The amplified IF analog signal produced by the RF front-end is fed to an analog-to-digital-converter (ADC).
- The digital output of the ADC is then fed to a Field Programmable Gate Array (FPGA).
- The FPGA extracts the "I" and "Q" components of the signal.
- The "I" and "Q" signal pair is called a complex signal. It is produced in the FPGA by two frequency mixers having a phase shift of 90° between them.
- The I/Q output of the FPGA is then fed to the USB 2 programmable controller.
- The software defined radio, running on the PC, takes its I/Q data from the USB 2 controller. The SDR software...

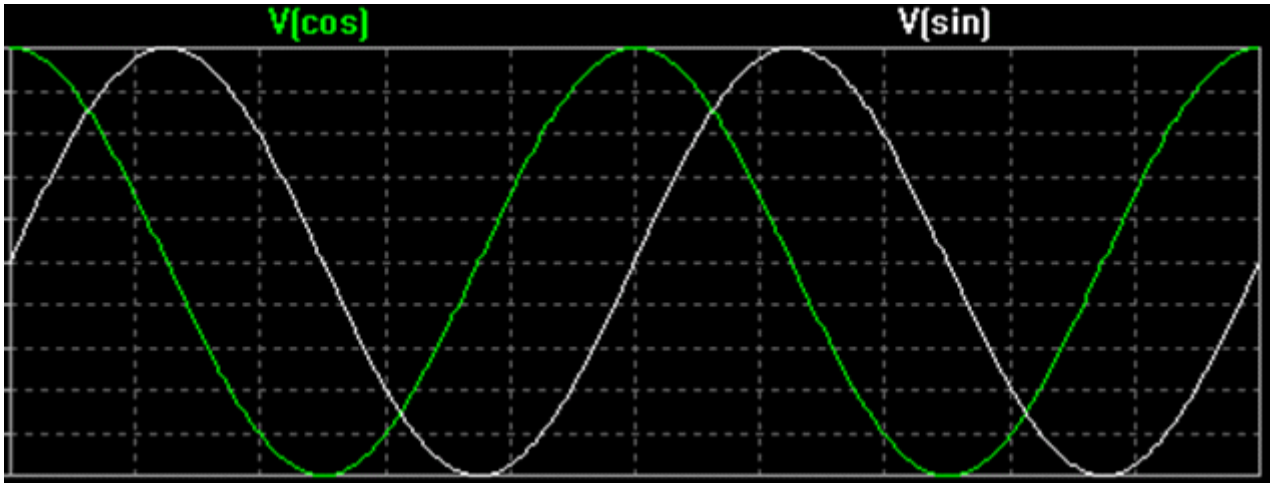
  ... extracts the information from the signal for audio output.

  ... displays a graphical user interface giving the user access to control functions and a variety of selectable visual outputs.
- All of the signal demodulation and spectral functions are done by the SDR software on your PC.
- Most SDR ham radio receiver implementations will usually (at least) support AM, WFM, USB, LSB, N-FM, DSB and CW with fully adjustable DSP filter bandwidths ... down to below 1 Hz in some cases!

From Analog to Digital:
Really, Really Superficially

- Let's review what an RF wave is...using a wave form from an oscilloscope which measures the signal frequency over time
- But note: it's only rapid *samples* of the RF signal, not the fully continuous wave
- Left is unmodulated RF; Right is unmodulated RF 90° out of phase. *This is IQ or Quadrature Sampling...what makes SDR work*

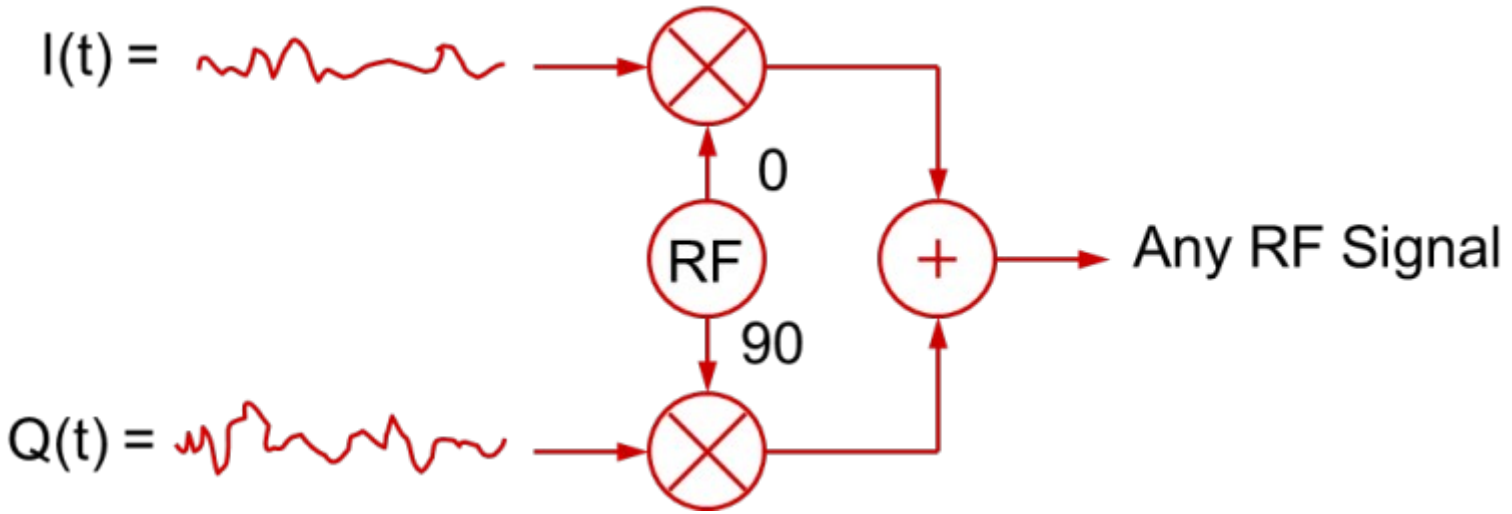




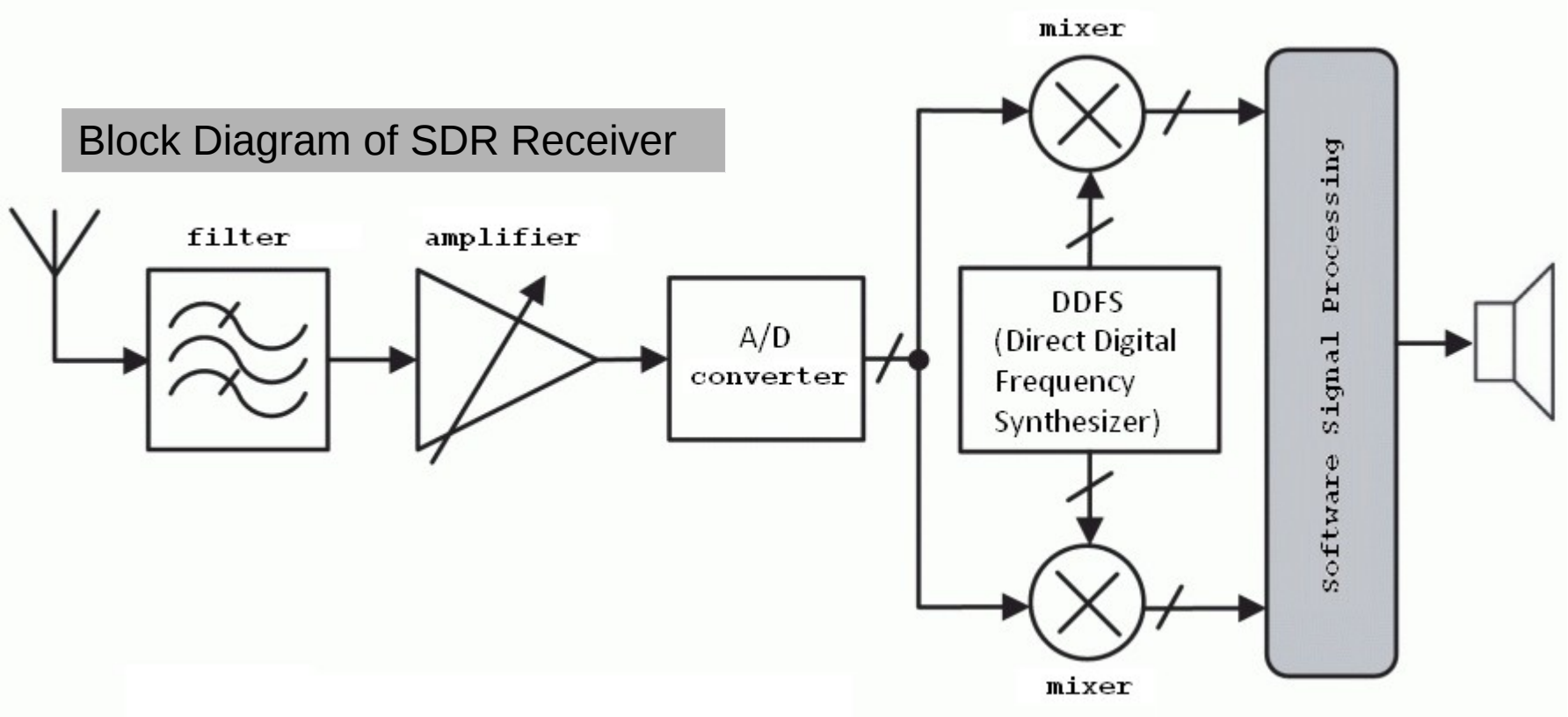
Source: http://www.tek.com/blog/what%E2%80%99s-your-iq-%E2%80%93-about-quadrature-signals%E2%80%A6

Getting I/Q

- Convert the “full” analog signal to a “sampled” digital stream using an A/D conversion. This takes place using a “field programmable gate array” (FPGA). (*Try that with a cat whisker!*)
- You can draw from this is that *a RF signal with any type of modulation can be created with the appropriate I(t) and Q(t) baseband signals* (which in turn vary the amplitudes of the cosine and sine waves that are summed together)
- Of course, the same process works *in reverse* to demodulate an RF signal. By mixing an RF signal with LO (local oscillator) signals in quadrature, I(t) and Q(t) baseband signals can be created

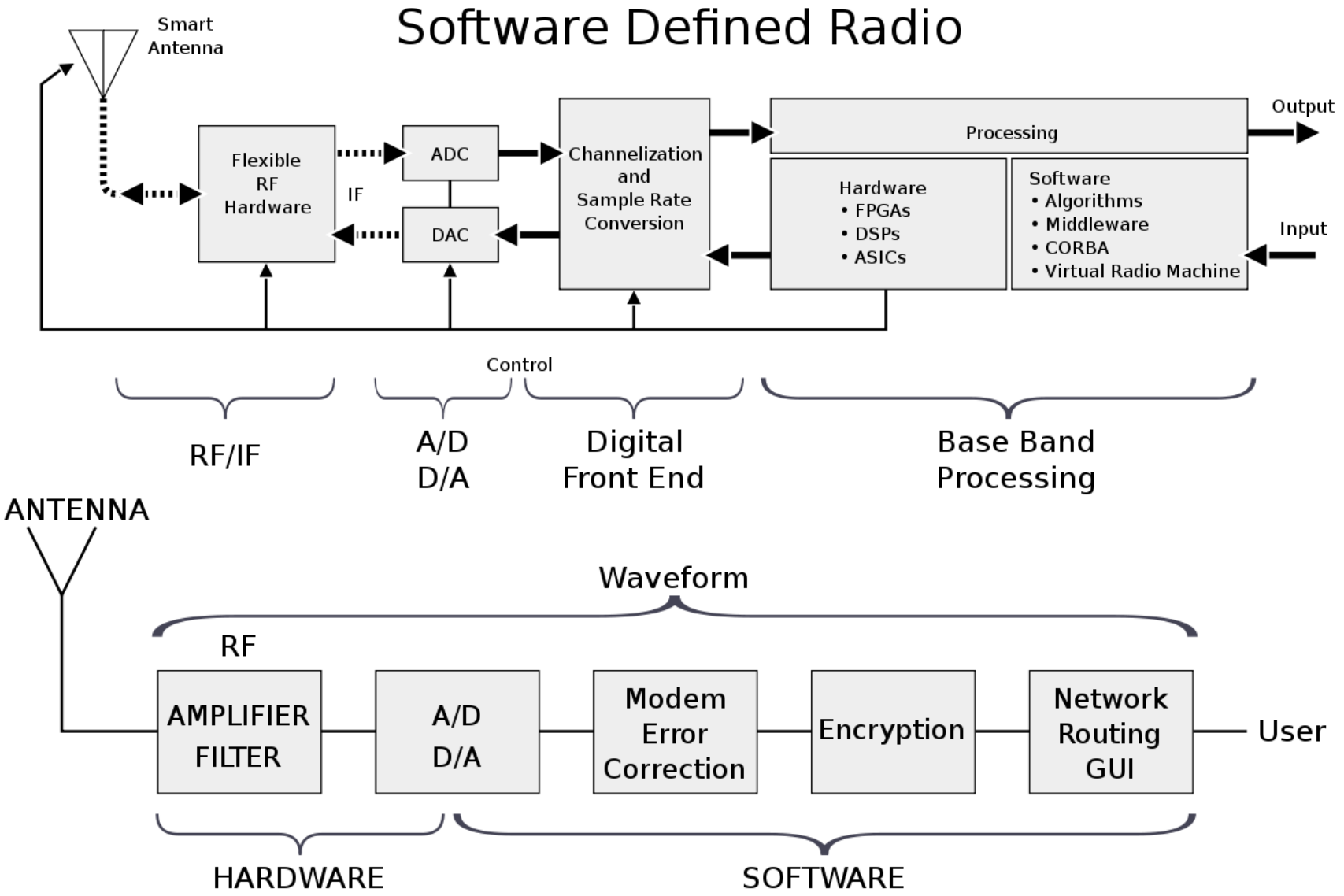


SDR Rx Block Diagram



Source: http://pandatron.cz/elektronika3/sdr5_fig1_big.jpg

Block Diagram of SDR Transceiver



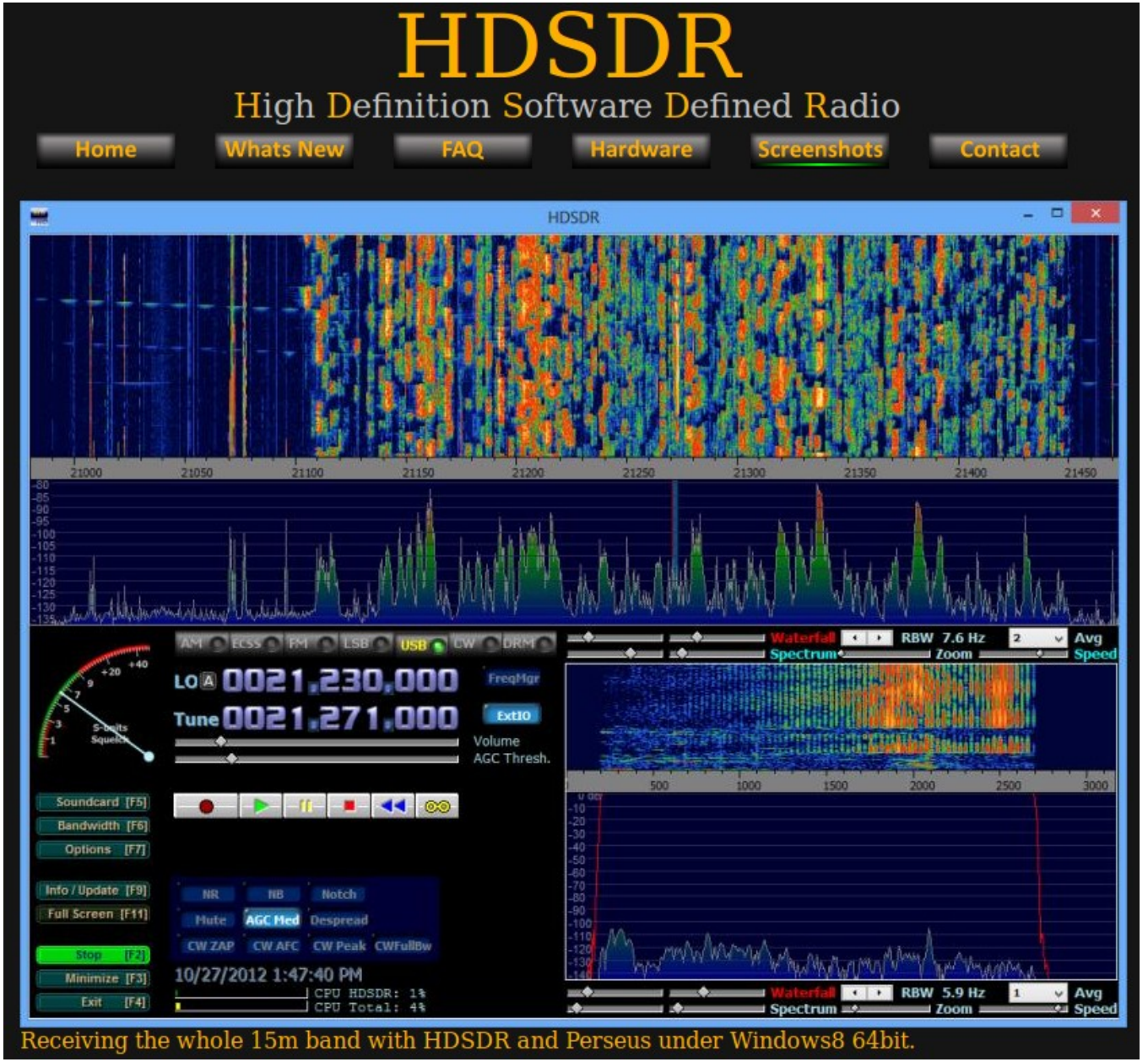
Coherent Genesis for Amateur Radio

- *A Software-Defined Radio for the Masses* by Gerald Youngblood, AC5OG
- This series describes a complete PC-based, software-defined radio that uses a sound card and an innovative detector circuit.
  - Part 1 QEX Jul/Aug 2002, pp. 13-21
  - Part 2 QEX Sep/Oct 2002, pp. 10-18
  - Part 3 QEX, Nov/Dec 2002, pp. 27-36
  - Part 4 QEX, Mar/Apr 2003, pp. 20-31
- Resulted in Youngblood helping to found Flex Radio Systems

Cool SDR Aspects

- Panadapter (rifle scope vs. regular vision)
- Filters! Brick-wall envelopes...software updatability vs. physical install
- Audio & IF DSP
- Software updates
- Where's the computer?
  - External (via USB or Firewire) vs. built-in the SDR box
- More than one VFO/Rx
- Other tricks
  - recording the bandwidth;
  - recording/playback of audio)

Panadapter!


HDSDR
High Definition Software Defined Radio
Home
Whats New
FAQ
Hardware
Screenshots
Contact
HDSDR
21000
21050
21100
21150
21200
21250
21300
21350
21400
21450
AM
ECSS
FM
LSB
USB
CW
DRM
LO A 0021,230,000
Tune 0021,271,000
FreqMgr
ExtIO
Volume
AGC Thresh.
Soundcard [F5]
Bandwidth [F6]
Options [F7]
Info / Update [F9]
Full Screen [F11]
Stop [F2]
Minimize [F3]
Exit [F4]
NR
NB
Notch
Mute
AGC Med
Despread
CW ZAP
CW AFC
CW Peak
CWFullBw
10/27/2012 1:47:40 PM
CPU HDSDR: 1%
CPU Total: 4%
Waterfall
Spectrum
RBW 7.6 Hz
Zoom
Avg
Speed
500
1000
1500
2000
2500
3000
RBW 5.9 Hz
Receiving the whole 15m band with HDSDR and Perseus under Windows8 64bit.

Not So Cool Aspects

- Price!
- DSP can sound tinny or non-mellow (not your father's tube radio or even solid-state analog audio)
- Rapid technological change...so trade rigs every 2 years to stay on bleeding edge
- No knobs (but they can be added!)
- Powerful PC as total cost of ownership

Innovation:
Open Hardware & Software Radio

- More expensive: http://openhpsdr.org
- Less expensive: http://sdr.osmocom.org/trac/
- List of SDRs: http://en.wikipedia.org/wiki/List_of_software-defined_radios
- 10 Things You Can Do with SDR:
  - Radio astronomy
  - Track ships via AIS transmissions
  - Track aircraft via Mode S transmissions
- Amateur Radio Foundation for SDR: see http://www.arrl.org/software-defined-radio
- 20% of ARRL Members in Delta Division have SDR...versus 27% with APRS and 12% with D-STAR

Commercial SDR Rigs:
What I Use

Perseus SDR Receiver: 10 KHz - 40 MHz

http://microtelecom.it/perseus/

Flex 3000 Transceiver: 1.8 - 30 MHz

(CW, J3E (USB, LSB), (AM), (FM), DIGITAL

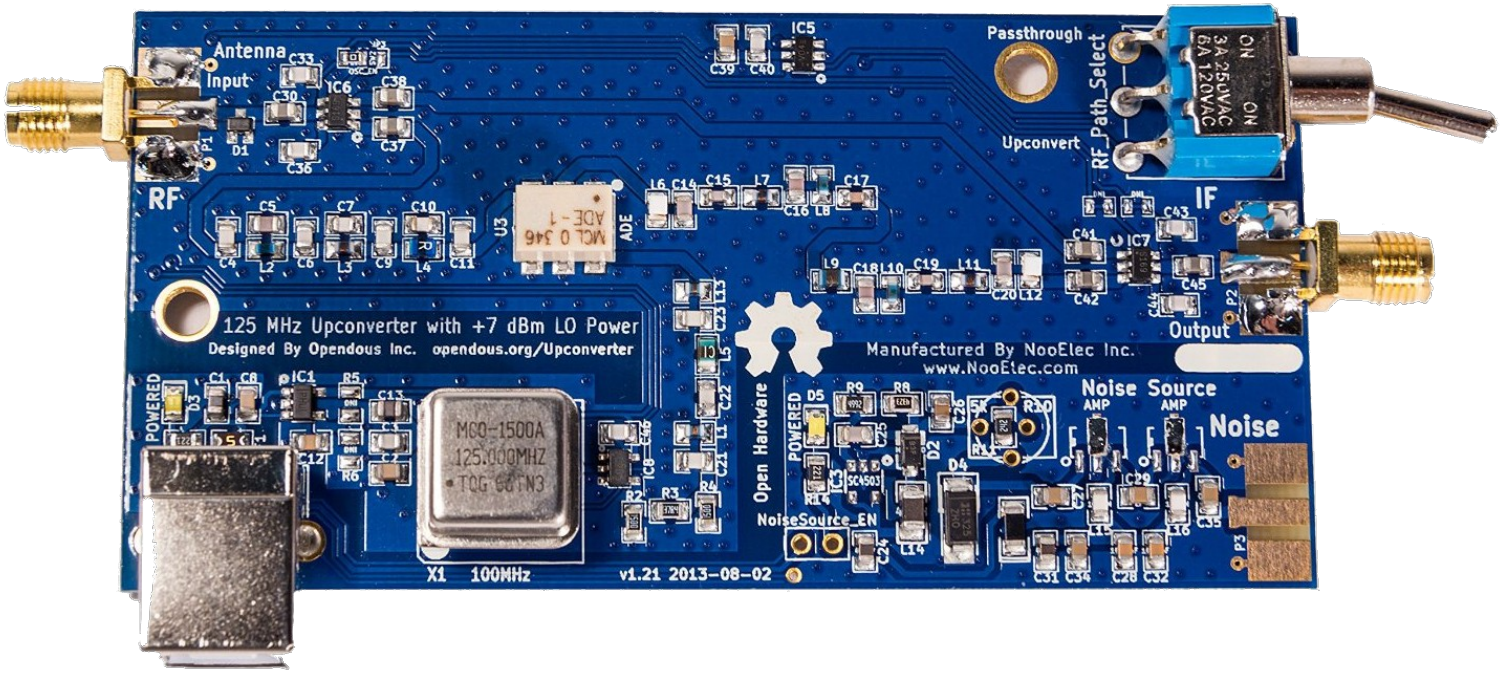
http://kc.flex-radio.com/KnowledgebaseArticle50352.aspx

The Catalyst for Hams: RTL Dongle

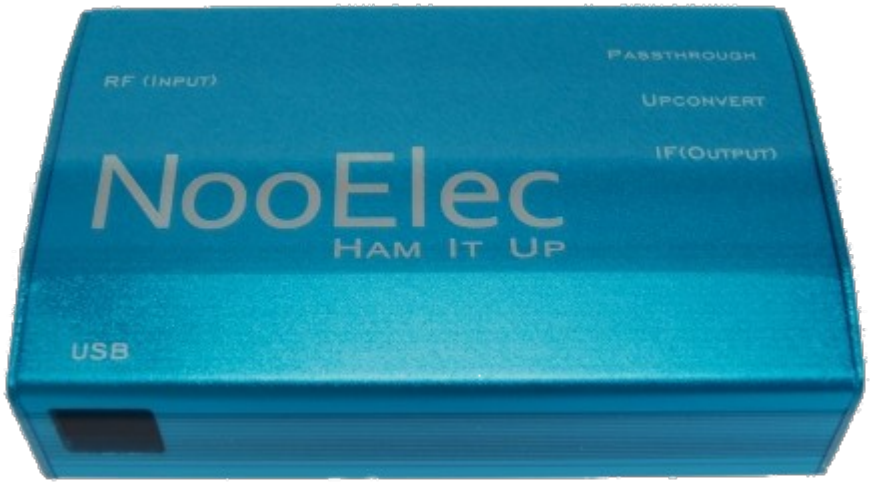
- see http://www.rtl-sdr.com
- Designed for mobile TV reception outside the US (esp. Europe)
- Italian ham realized that the hardware was broadband--very broadband--so he wrote a new firmware that can be used with the TV dongle and a PC to yield Software Defined Radio Reception
- Cheap! Began around $100 but now down to $10 or less for some models

RTL Dongle

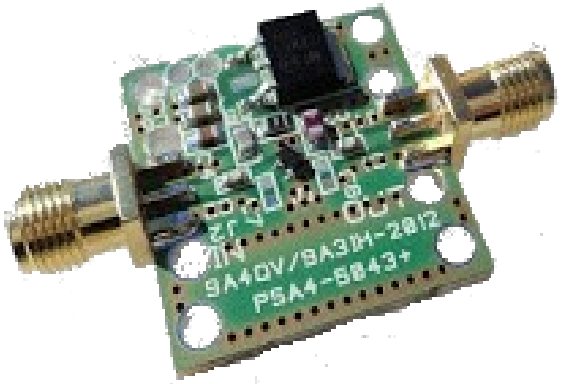
- Frequency coverage...
- Need a converter to add HF coverage.
- Open Source version: UpVerter by NOOELEC

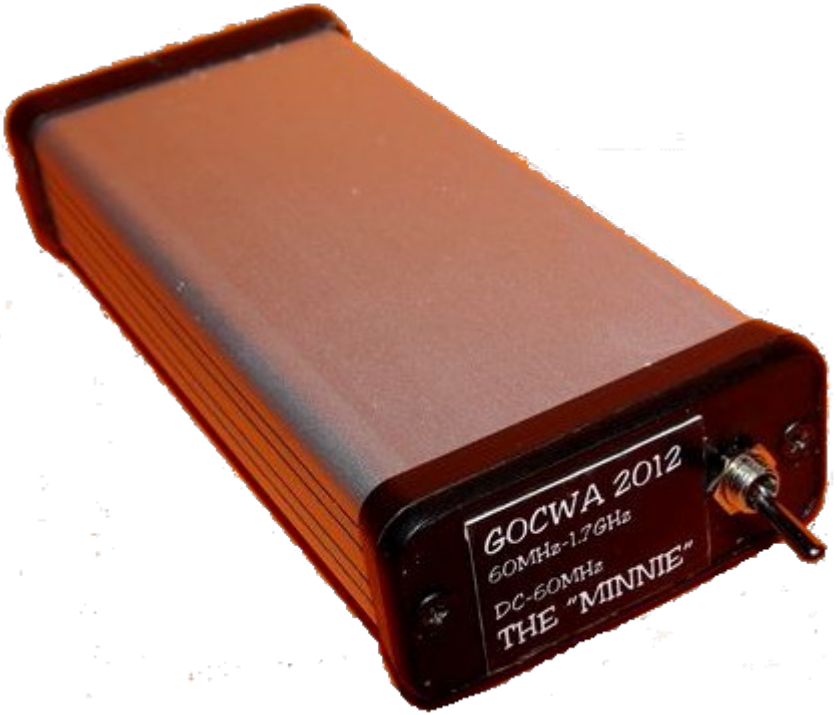


Nice Add-Ons


RF (INPUT)
PASSTHROUGH
UPCONVERT
IF(OUTPUT)
NooElec
HAM IT UP
USB

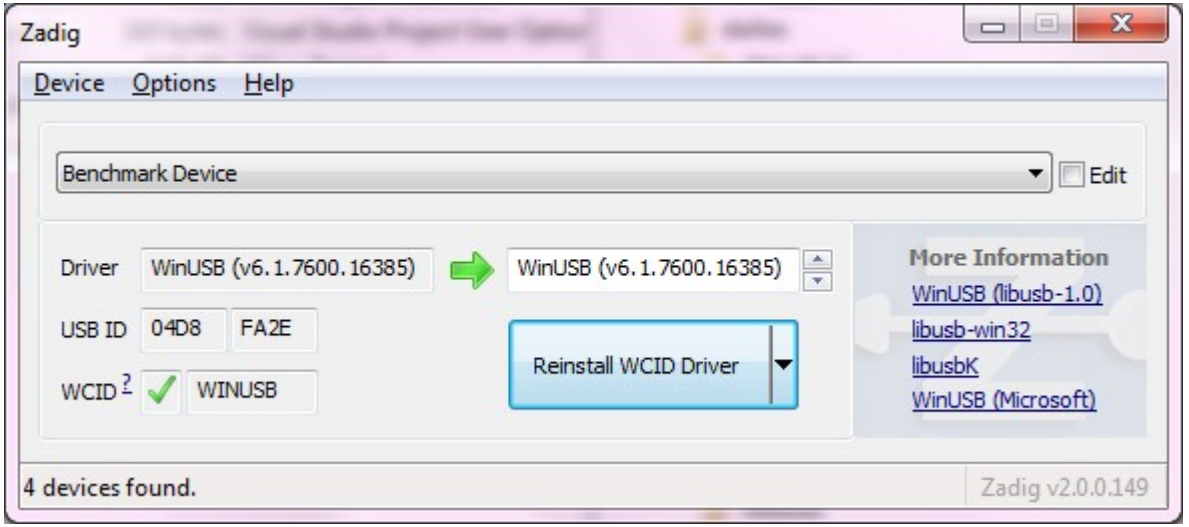

NooElec
www.nooelec.com




GOCWA 2012
60MHz-1.7GHz
DC-60MHz
THE "MINNIE"

Setup Instructions

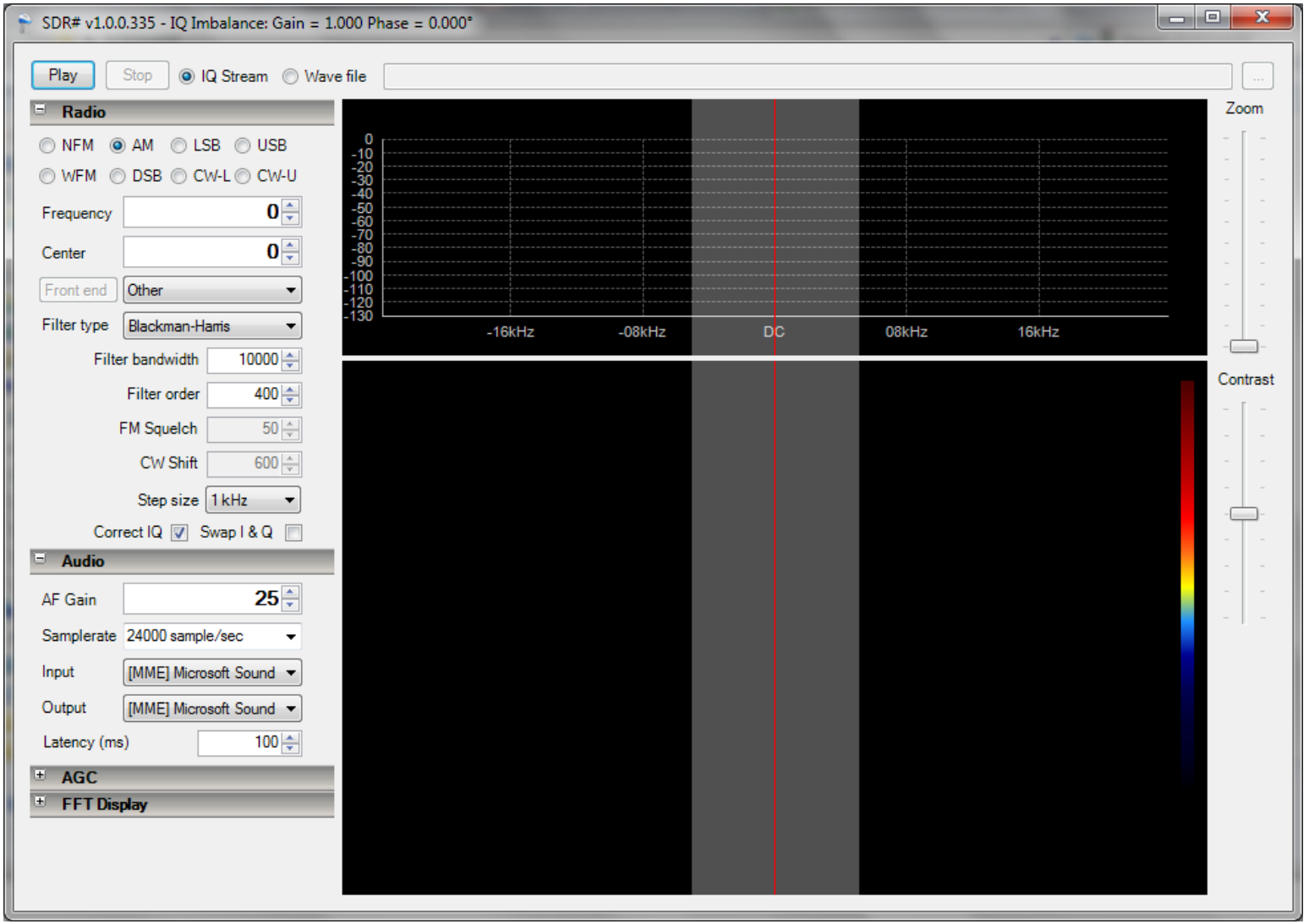
- (Windows) PC needs a different “driver” installed or else the OS sees the dongle as a generic USB device
- Download Zadig driver from http://zadig.akeo.ie
- Driver install dialog box:



Automated Installer!

- **Automated Installer:**
- Download sdr-install.zip and unzip it. Double click on the install.bat file in the newly created sdr-install directory to have the script download everything you need including Zadig.
- You might find on occasion when re-running install.bat to update SDR# that it doesn't seem to get the latest version. In this case you will need to clear the cache in IE as shown here.
- Once the script has completed it will have downloaded the latest SDR#, the latest RTL driver from Osmocom (and enabled use of RTL-USB) and Zadig and put them in a new sdrsharp directory.
- If you haven't already run Zadig to set up your RTLSDR dongle for use with SDR# for the first time follow the Zadig instructions above (skipping the step to download Zadig) to configure the correct USB driver.
- Once the the WinUSB driver is installed you are ready to run SDR# with the RTL-SDR/USB input device.

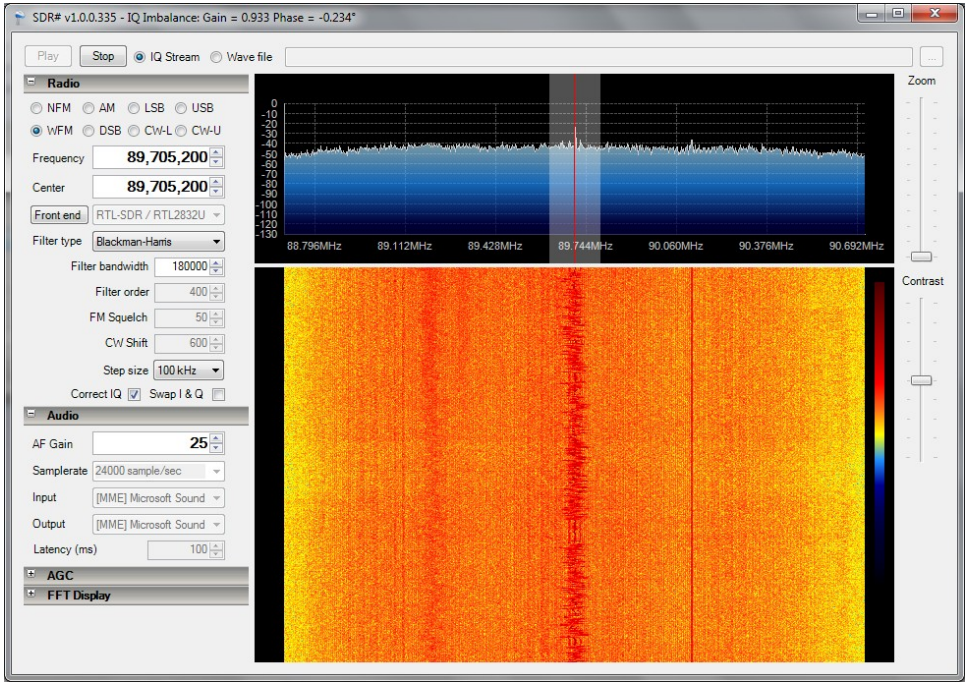
Run SDR# (“sharp”)



Settings

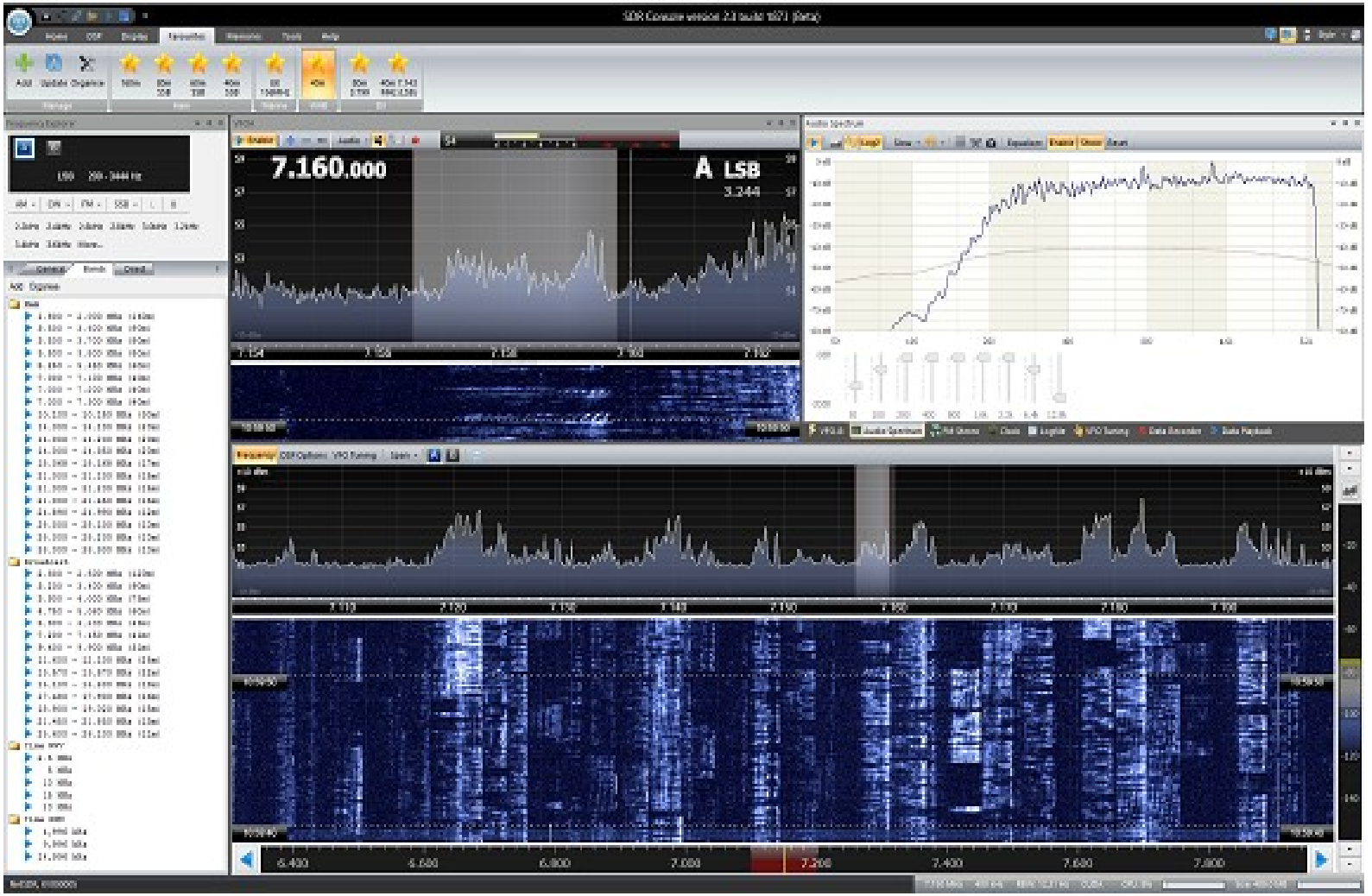
To get started, set the following:

- Set Radio to WFM (wideband FM)
- Set the centre frequency to (88,000,000) This is 88MHz, the start of the FM radio band in most countries.
- Set the 'Front End' type from 'Other' to 'RTLSDR / USB'
- If all is working the 'Front End' button should go from grey text to black text.
- Click on Play.

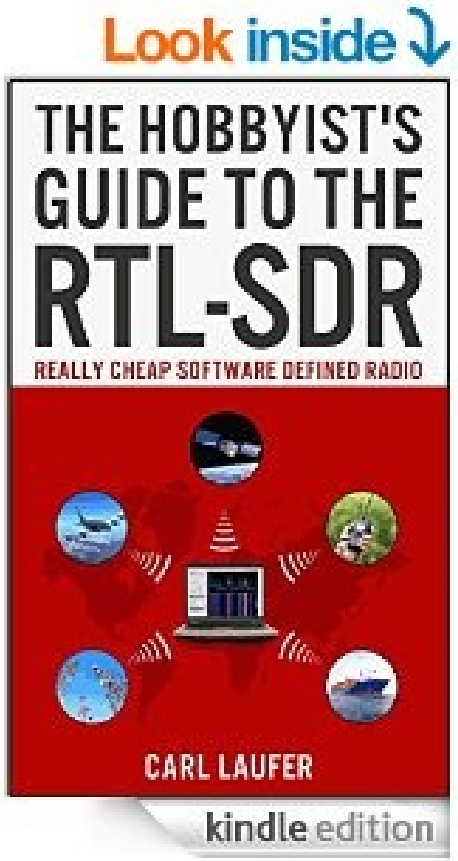


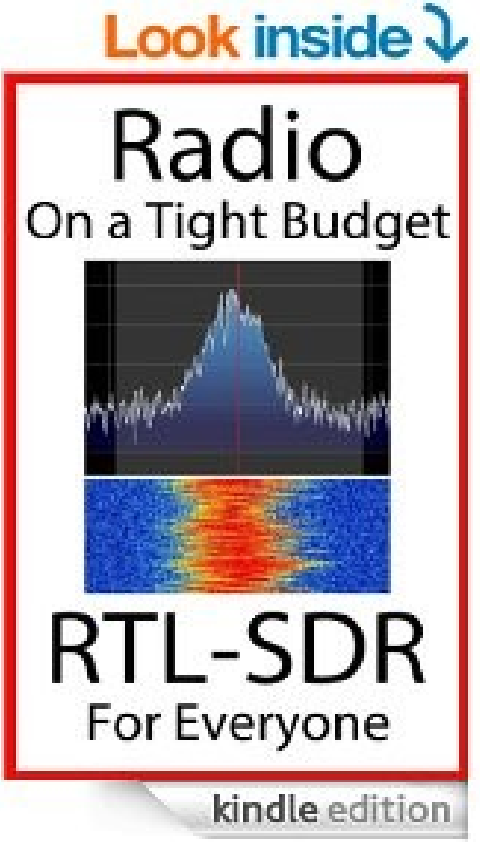
Other SDR Software

- I like **SDR-Console** by Simon Brown (http://http://v2.sdr-radio.com/)



More Info on SDR





Thanks for Listening!

Blog: k4fmh.com