Introduction to
Software Defined Radio (SDR)
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Thanks for all the help!

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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 your 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)

ADC

Convert the analog signals on the antenna to digital signals (0's and 1's)
How does SDR work? (in practice)

Analog filter to avoid overloading

IF stage so that the ADC could sample high frequencies

Digital controlled oscillator (DCO)

IQ output so we can sample +/- frequencies from the DCO (measure freq, phase, amplitude)
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

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
Fast Fourier Transform (FFT)
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

IQ Input → Low Pass Filter → Demodulator → Audio Output

The input from the ADC selects only the information you want, then 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
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 your own: [http://www.george-smart.co.uk/wiki/FunCube_Upconverter](http://www.george-smart.co.uk/wiki/FunCube_Upconverter)
  - Buy from eBay: ~$40 (have never bought one)
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](http://software.muzychenko.net/eng/vac.htm)
  - Install jack audio (free, but Good luck)
    - [http://jackaudio.org/](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:

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
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://wb5rvz.com/sdr/
- http://sdrsharp.com/
- http://www.baycom.org/~tom/ham/soundmodem/
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- http://www.pe0sat.vgnet.nl/tag/sdrsharp/
- 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
Live Demo...
And Questions.