Intro to the RTL-SDR & other SDR stuff

Jim Nagle - KF4OD
Outline

1. What is a Software Defined Radio?
2. What can SDR do for me?
3. How does SDR work?
4. SDR Hardware (what is an RTL-SDR)
5. SDR Software
6. A Few Links to Get Started
7. Live demo and Questions
   (possibility for answers is questionable)
What is Software Defined Radio (SDR)

- A basic SDR system may consist of a **personal computer** equipped with a **sound card**, or other **analog-to-digital converter**, preceded by some form of **RF front end**.
- Significant amounts of **signal processing** are handed over to the general-purpose processor, rather than being done in special-purpose hardware.
- Such a design produces a **radio** which can receive and transmit widely different radio protocols (sometimes referred to as waveforms) based solely on the software used.
- In the long term, software-defined radios are expected to become the dominant **technology** in **radio communications**.
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 (could fit on the palm of your hand) and low cost for all of these features.

You just need to connect the USB dongle to an antenna, and via the OTG (On-The-Go) cable to your Android device and run SDR Touch! It is that simple!
What can SDR do for me?

Plot Airplane flight paths along with weather and other sensor data using ADS-B
What can SDR do for me?

Plot vessels using the **Automatic Identification System (AIS)** tracking system used on **ships** and by **vessel traffic services** (VTS) for identifying and locating **vessels** by electronically exchanging **data** with other nearby **ships**, AIS base stations, and satellites.
What can SDR do for me?

Enable an APRS monitor and iGate server
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.
How does SDR work?
How does SDR work? (in theory)

Convert the analog Signals on the antenna to digital (0’s and 1’s)

Use Signal Processing Techniques to perform Filtering and Demodulation
How does SDR work?
(in theory)

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 higher frequencies

IQ output so we can sample +/-frequencies from the DCO (measure frequency, phase, amplitude)
How does SDR work?
(in practice)
SDR Direct Conversion
(One Down Conversion To Baseband)

With only one analog down conversion before digitizing the signals, there is less opportunity to introduce distortion than in the multi-conversion design.

The Elecraft KX3 is an example of a Direct Conversion SDR.
SDR Hardware
SDR Hardware
What you need to get started

Antenna
Hardware to convert the signals from the antenna to the processor (~$15)

Signal processor & Software
SDR Hardware

Low Cost

TX/RX
- UHFSDR
- SoftRock
  Uses soundcard as 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?

Or

Rhode+Schwarz
$45,000

Or

RTL-SDR
$15
SDR Hardware

You can always build your own...
R820T RTL-SDR dongle

- Cheapest option for an entry level SDR receiver unit
- Developed as a Digital Video Broadcast – Terrestrial (DVB-T) and Digital Audio Broadcasting FM (DAB-FM) receiver
- Uses the Realtek **RTL2832U** demodulator
- While messing around with a DVB-T dongle someone found that the tuner can handle more than just the FM and TV bands
- Can tune from approx. 26Mhz to 1.7Ghz
- View up to a 2.5Mhz slice of spectrum
- Can be used with many different software utilities
- **You get what you pay for!**
SDR Software
SDR Software

• Software developed for hardware specific, proprietary, open source, closed source and for different platforms

• Numerous “free” SDR software utilities are available

• Pick the correct software that matches your needs

• Some Popular Software Titles are:
  - SDR#
  - SDR-Radio
  - HDSDR
  - Modified Versions of PowerSDR (NaP3 for example)
  - SpectraVue (RF Space)
  - Rocky (Great for Softrock)
  - GNU Radio (Linux)
SDR Software

All SDR software have similar GUI modules
SDR Software
The heart of SDR.
Performs the computations for the radio part.
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
How to use the SDR Software
Filters and Tuning

Filters and Tuning allow us to get only the information we want
GnuRadio The Swiss army knife of SDR
**WebSDR**

- A WebSDR is a Software-Defined Radio receiver connected to the internet, allowing many listeners to listen and tune it simultaneously.
- SDR technology makes it possible that all listeners tune independently, and thus listen to different signals; this is in contrast to the many classical receivers that are already available via the internet.
http://websdr.ewi.utwente.nl:8901/
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
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

Buy on line:
UV HF RTL-SDR USB Tuner Receiver/ R820T+8232  100KHz-1.7GHz


http://www.nooelec.com/store/
But What If I Want To Transmit?

- There are SDR radios that allow you to transmit.
- Generally more expensive than standalone receivers
- Fewer software choices that allow for TX
- Some of the popular SDR Transceivers are
  - Flex Series Radios (1500, 3000, 5000, 6300, 6700) / $700-$7500
  - Hermes (Apache Labs ANAN-100D/200D) / $1700-$4000
  - Peaberry – 1W $150
  - Softrock RX/TX – 1W $89 Kit
  - Elecraft KX3
TX Alternative... Use your existing HF Rig

- Possible to add SDR Capabilities to your existing HF Radio
- Some radios have IF output already included
- Some rigs can be adapted or modified to provide an IF output freq
- If the SDR Hardware can receive the IF frequency then it’s possible
- SDR Software available to control the rig while locking the SDR tuned to the IF frequency of your main rig.
- Depending on the hardware, it’s also possible to view the TX signal like a station monitor.
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
A Few Links to Get Started
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- http://www.rtl-sdr.com/
- http://rtlsdr.org/
- http://www.sigidwiki.com/
- http://markslab.tk/project-artemis/
- http://sdrsharp.com/
- http://www.hdsdr.de/
- http://v2.sdr-radio.com/
- http://websdr.org/
Live Demo... And Questions.