An Amateur’s amateur guide to Software Defined Radio (SDR)

Presented by Ethan Waldo

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About Me

• Learned from a co-worker about the existence of amateur satellites and Cubesats around December 2012
  – http://science.slashdot.org/story/12/12/19/2310252/ask-slashdot-how-would-you-build-a-microsatellite
• Joined AMSAT on 1/23/2013
  – Learned about the importance of amateur radio communication
• Ordered a Realtek TV Tuner commonly used for SDR on 2/3/2013
• Ordered the ARRL Tech license manual on 2/11/2013
• Took and passed the Tech exam on 3/2/2013 and received FCC license on 3/7/2013
• Defined a functioning NFW SDR and successfully listened to the Swapfest at 146.94 on 3/23/2013
What is Software Defined Radio (SDR)?

• A software-defined radio system, or SDR, is a radio communication system where components that have been typically implemented in hardware (e.g. mixers, filters, amplifiers, modulators/demodulators, detectors, etc.) are instead implemented by means of software on a personal computer or embedded system. -Wikipedia

http://en.wikipedia.org/wiki/Software-defined_radio
Why SDR?

- Provides a very low cost entry in to amateur radio
- Takes up little physical space
  - Portability
- Mature software variety and operating flexibility
- Wide range of radio spectrum
- Can appeal to the novice all the way up and beyond the radio engineer
- Usage is increasing in space
  - FOX-1 in US
  - Funcube in UK
Equipment

- Realtek RTL2832U+R820T
  - A USB device primarily intended for receiving DVB-T, FM, and DAB, but Antti Palosaari discovered sample data was unlocked and demodulation is performed in software
    - [http://thread.gmane.org/gmane.linux.drivers.video-input-infrastructure/44461/focus=44461](http://thread.gmane.org/gmane.linux.drivers.video-input-infrastructure/44461/focus=44461)
  - 24Mhz to 1.85Ghz range
    - Lower HF bands available with upconverters
      - [http://www.george-smart.co.uk/wiki/FunCube_Upconverter](http://www.george-smart.co.uk/wiki/FunCube_Upconverter)
  - $10-$12 including shipping on Ebay
    - Most sold directly from China so 1-2 week wait typically
  - Discontinued E4000 tuner very popular but frequency range not quite as wide
  - USB connection can be extremely flaky
Equipment
Equipment

• Opek VU-1510 VHF/UHF Dual Band Magnet Monopole Anenna from AARadio for about $20
• SMA Male to UHF Female jumper cable from AARadio for about $15 (out of stock of the $6 connector and I couldn’t wait)
• GlobalSat MCX-to-SMA Female jumper cable from Amazon for about $8 (sadly AARadio doesn’t carry much MCX currently)
• Acer C7 Chromebook running ChrUbuntu $200
• Char-Broil Red grill for ground plane: Priceless (or about $400)

Total Cost sans Laptop and grill: $50-60
Equipment
Equipment Disclaimer

- Bought BAOFENG UV-5RE and USB programming cable from Amazon for about $65 to serve as reference device
  - recommendation from co-worker and a couple of Austin Hams who can remain anonymous if they like
- Was difficult to verify my SDR was working
  - 14cm monopole that came with RTL not great for picking up 2m
  - Didn’t expect 146.94 repeater to be so quiet
    - sometimes no chatter for days at a time
  - Knowledge from Internet and ARRL books not clear on whether amateur 2m used WFM or NFM
Microsoft Windows Software
Software (SDRSharp)
Software (SDRSharp)

• Somewhat Open Source SDR software
  – GUI and plugin parts under MIT license
  – DSP under MS-RSL (Boooo!)

• Download and install from http://sdrsharp.com
  – Under “Important note for RTL-SDR users” download
    http://sdrsharp.com/downloads/sdr-install.zip instead for quick install

• Follow instructions at http://rtltsdr.org/softwarewindows for Zadig to install special windows driver
Software (SDRSharp)
Software (SDRSharp)
Software (HDSDR)
Software (HDSDR)

- Freeware closed source SDR software
  - Formerly WinRad
- [http://wiki.spench.net/wiki/USRP_Interfaces](http://wiki.spench.net/wiki/USRP_Interfaces)
  - Click Download
  - Download from Mirror
    - [http://users.on.net/~balint/ExtIO_USRP+FCD+RTL2832U+BorIP_Setup.zip](http://users.on.net/~balint/ExtIO_USRP+FCD+RTL2832U+BorIP_Setup.zip)
  - Unzip and install
    - Choose at least libusb, VC++ Runtime, EXTIO_USRP+FCD+RTL2832U + BorIP, and HDSDR
    - Skip over Zadig installation since we already installed from SDRSharp
Software (HDSDR)

- Download EXTIO_RTL.dll from [https://github.com/josemariaaraujo/ExtIO_RTL](https://github.com/josemariaaraujo/ExtIO_RTL) and copy to HDSDR folder
Software (HDSDR)
Linux Software
Software (GnuRadio)
Software (GnuRadio)
Software (GnuRadio)

• Completely Free/Open Source SDR software
  – Recommended: Using the build-gnuradio script
    • Fedora and Ubuntu distros, Debian on the way
    • wget http://www.sbrac.org/files/build-gnuradio &&
    chmod a+x ./build-gnuradio && ./build-gnuradio
    • Build dependency requirements may vary but unfortunately outside the scope of presentation
Software (GnuRadio)

  - Install Git
    - “apt-get install git” for Ubuntu
    - “yum install git” for Fedora
  - git clone git://git.osmocom.org/rtl-sdr.git
  - Follow building the software section
- Gr-baz for additional GnuRadio blocks
  - [http://wiki.spence.net/wiki/Gr-baz](http://wiki.spence.net/wiki/Gr-baz)
    - git clone https://github.com/balint256/gr-baz.git
  - [http://wiki.spence.net/wiki/RTL2832U](http://wiki.spence.net/wiki/RTL2832U)
- GRC for example RX/TX radios
    - git clone https://github.com/csete/gnuradio-grc-examples.git
- CGRAN for free open source 3rd party unsupported GnuRadio applications
  - [https://www.cgran.org/wiki/Projects](https://www.cgran.org/wiki/Projects)
- 146.94 compatible NFW receiver completed by Ethan Waldo (KF5UFH)
- [http://www.youtube.com/watch?v=_hGNT1w-jig](http://www.youtube.com/watch?v=_hGNT1w-jig)
Networking Radio

- Allows the physical radio device and antennae/coax cable run to be located at a different location from where the SDR software runs without additional dB loss
- Wifi latency too high, recommend using wired Ethernet or equivalent
- BorIP for GnuRadio and HDSDR
- rtl_tcp for GnuRadio and SDRSharp
Networking Radio (BorIP)

- [http://wiki.spench.net/wiki/Gr-baz](http://wiki.spench.net/wiki/Gr-baz)
  - git clone [https://github.com/balint256/gr-baz.git](https://github.com/balint256/gr-baz.git)
- Needs Python 2.7+
- Run “lsusb” to get VID/PID from RTL device
  - i.e. Bus 002 Device 008: ID **Obda:2382** Realtek Semiconductor Corp. RTL2832U DVB-T
    - **Obda** is VID, **2382** is PID
- Under gr-baz/apps modify borip_RTL.py
  - `self.source.set_vid(0xFFFF)` #Where FFFF is VID
  - `self.source.set_pid(0xFFFF)` #Where FFFF is PID
  - `self.source.set_sample_rate(2000000)`
  - Run “python borip_server.py –vrgc”
Networking Radio (HDSDR + BorlIP)
Networking Radio (HDSDR + BorIP)
Networking Radio (rtl_tcp)

- rtl_tcp should be installed when rtl-sdr is installed
- Run "rtl_sdr --a <IP Address>" where <IP Address> is the bound IP of the local ethernet adapter you want the server to run on

```
Found 1 device(s).
Found Rafael Micro R820T tuner
Using Generic RTL2832U
Tuned to 100000000 Hz.
listening...
```
Networking Radio (GnuRadio + rtl_tcp)
What next for me?

- Listen to my first satellite QSO
- Start recording and deciphering satellite telemetry
- Research RX/TX capable SDRs and make more serious purchasing decision
  - Funcube Dongle Pro+ ([http://www.funcubedongle.com](http://www.funcubedongle.com)) $200
    - 150kHz – 250Mhz & 420Mhz – 1.9Ghz at 192kHz bandwidth
  - Noctar ([http://www.pervices.com](http://www.pervices.com)) $750-$850
    - 100kHz – 4Ghz at 200Mhz RX/250Mhz TX bandwidth
    - DC – 6Ghz RX/TX with various daughterboards
- Continue to improve the audio quality and power usage of my SDR configurations
- Select a design and build a directional Yagi antennae from scratch
  - Continue learning about antennae design
  - Model my own antennae in EZNEC or appropriate software
- Build an operable ground station at my place of residence
- Upgrade to General Class and Extra Licenses
- Start making Satellite and Terrestrial contacts
Questions or Recommendations???
Thank You

I would like to thank Andrew Duhan, Austin Hams, ARRL, AMSAT, and various Internet denizens for making this all possible. Feel free to contact me for any questions or assistance and I will gladly help as I have time available.

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http://bit.ly/10sCkTG