University of Toronto Coders

Information From the Air:
Software Defined Radio

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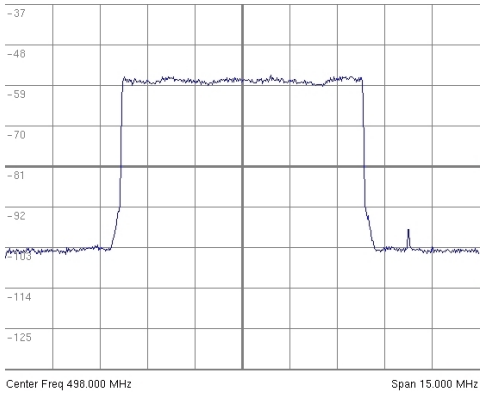
Communications Terms

- Rx – receive
- Tx – transmit
- simplex – one device Tx transmits, other Rx receives, e.g. broadcast TV
- half-duplex – Tx/Rx transmit/receive in both directions but one at a time, e.g. USB, WiFi, walkie talkie (transceiver)
- full-duplex – Tx/Rx transmit/receive both directions at the same time, e.g. two cans and a string, telephone, ethernet

Digital Television Broadcasting (2010)

- Euro + Asia DVB-T digital TV splits Tx data into >1000 frequency slices ‘spread spectrum frequency hopping’ (invented by Hedy Lemarr and George Antheil) Digital Video Broadcast (DVB) is the instantaneous signal across a <15MHz bandwidth



- North American ATSC digital TV – signal monitored across a 6 MHz bandwidth (🇨🇦 Aug 31, 2011)

- Early 2011, Finnish developer Antii Palosaari, developing DVB drivers for Linux, discovers a device mode for the Realtek RTL2823U chip- raw radio frequency (RF) data can be captured to a computer!

Open Source Drivers for Digital TV

This enables the device to be used not just for European Digital television signals but in a general way, as a ”Software Defined Radio” – for demodulating any RF signal. Virtual electronics. Ad hoc networks.

OSMOCOM = Open Source Mobile Communications
https://osmocom.org/

DVB-T USB stick: antenna, tuner, and analog to digital converter (A/D).

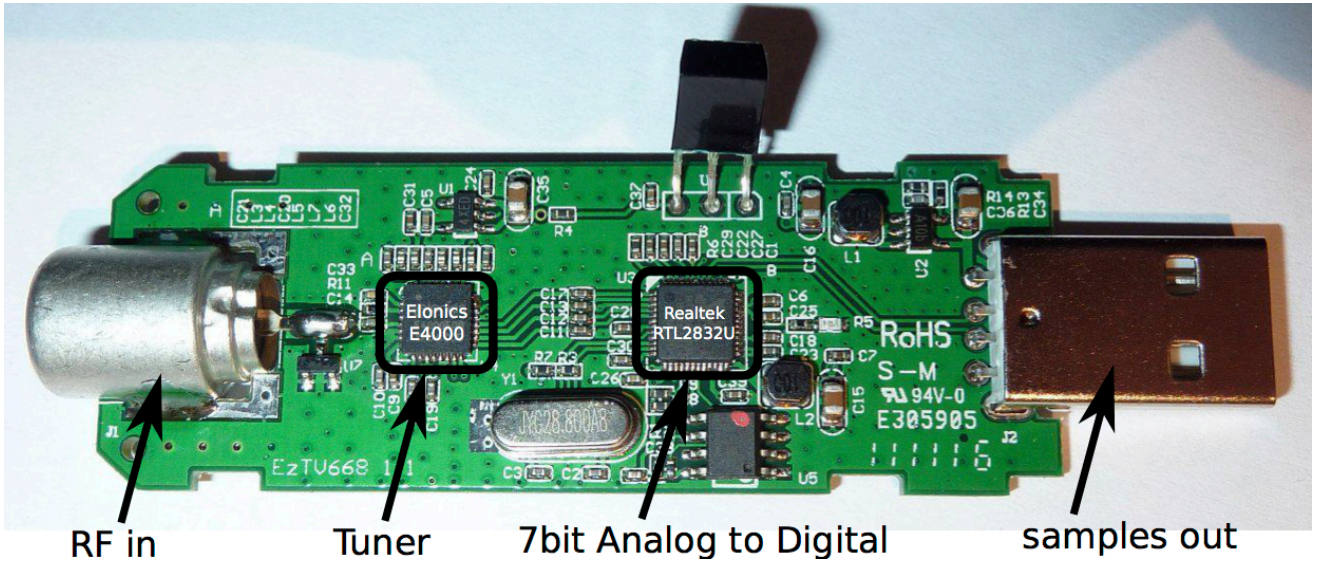
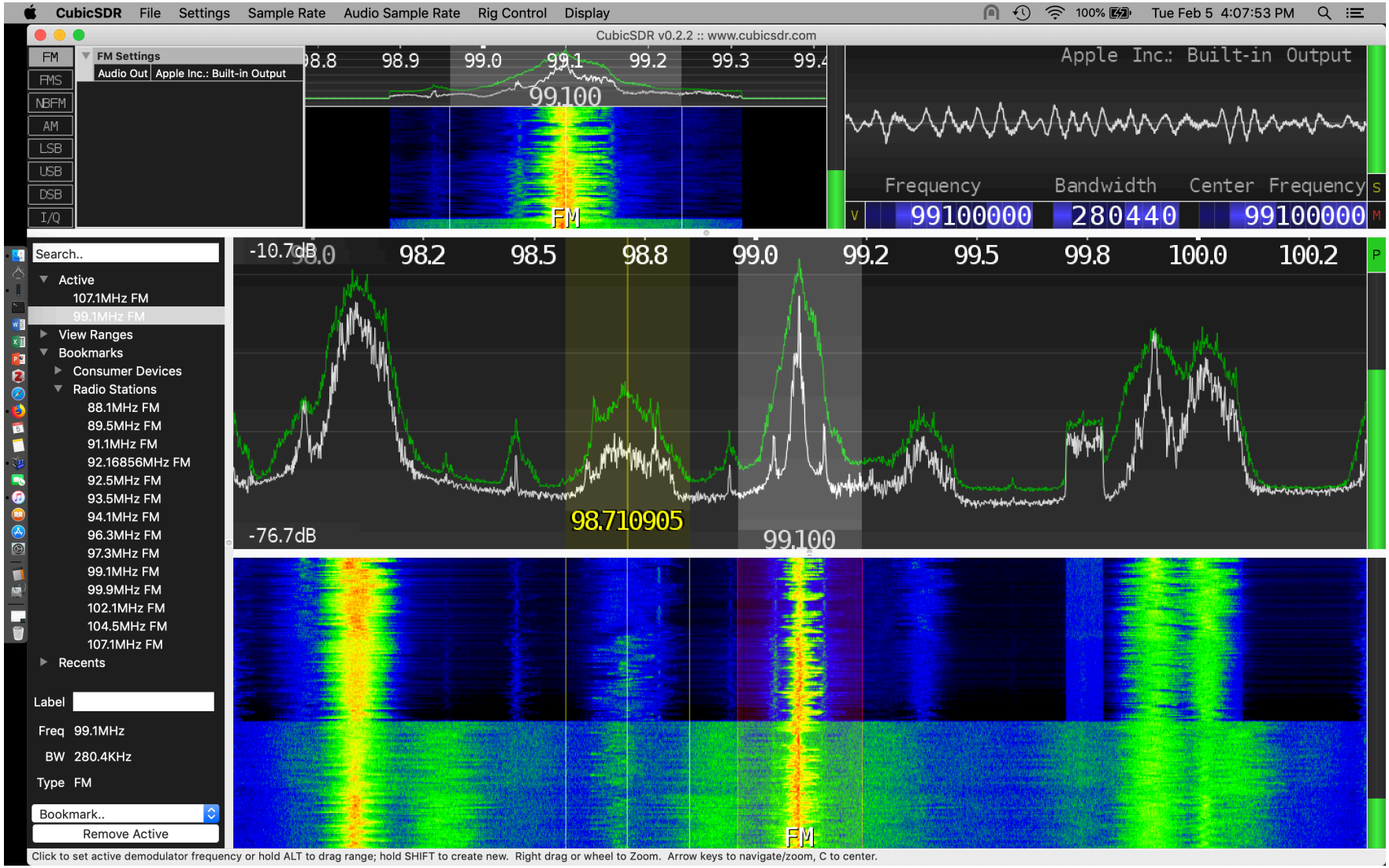


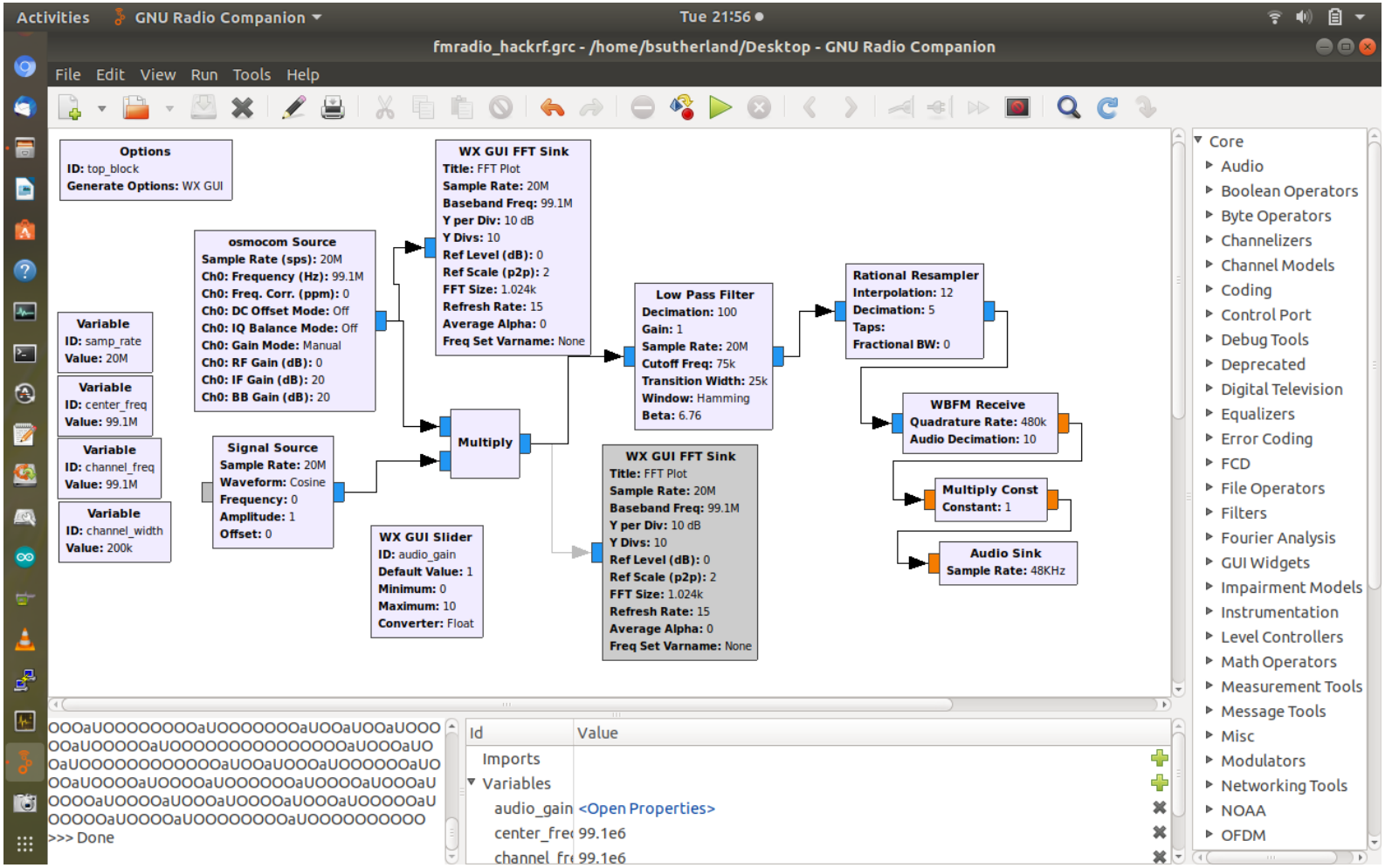
Image courtesy: https://inst.eecs.berkeley.edu/~ee123/fa12/rtl_sdr.html

Cubic SDR – Charles J. Cliffe



GQRx – Alexandru Csete

GNU Radio Companion – Flowgraph



Dragging blocks, setting values and connecting I/O creates RF python code.

Software Defined Radio Hardware

- A sound card for your PC, in the radio frequency spectrum
- “The RTL2832U outputs 8-bit I/Q-samples, and the highest theoretically possible sample-rate is 3.2 MS/s, however, the highest sample-rate without lost samples that has been tested so far is 2.56 MS/s” - OSMOCOM wiki

- $50 Nooelec Nano Three - **Rx**; Rafael Micro R820 Tuner 24 - 1766 MHz. Same profile as USB port, heat sink. Antenna sold separately and pops off easily.

- $10 - "RTL 2832U" **Rx;** Fitipower FC0012 Tuner 22 - 948.6 MHz works w/ Ubuntu 16, but not 18 Works great on OS/X

- $100 ‘YARDStick’ **half duplex (Rx & Tx)** < 1 GHz

- $500 HackRF **half duplex (Rx & Tx)** 1 MHz - 6 GHz

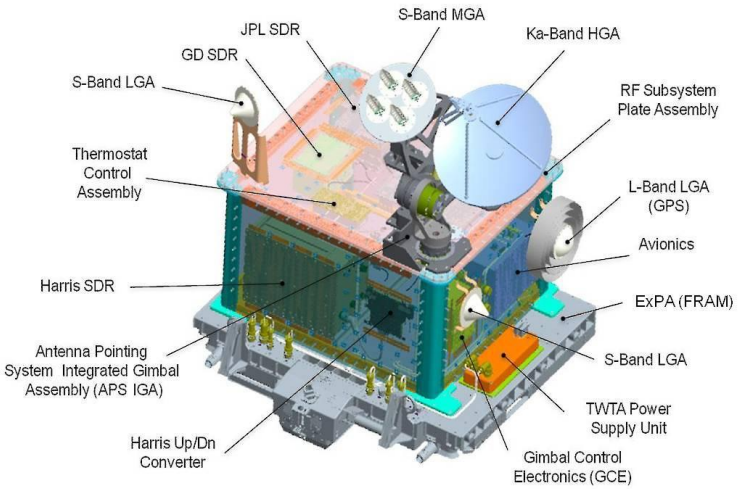
Command Line Utilities

- rtl_test -t (test hardware and return info)
- rtl_fm -f 99.1e6 -M wbfm -s 200000 -r 48000 - | aplay -r 48k -f S16_LE
- Guided Tutorial GNU Radio in Python
- FM Radio from GR Flowgraph Tutorial

What's out there in RF?

- AM/FM Radio
- Flight Aware ADS-B Crowdsourced Aircraft Tracking System 1090 MHz, 100-300mi range
- LoRA Internet of Things (868 or 915 MHz)
- Bluetooth (2.4 GHz)
- WiFi (2.4GHz and 5GHz)
- 4G (700, 850, 1700, 1900, 2100, 25/600 FDD)
- NOAA Satellite Images [antenna out of umbrella]
- Wireless Event Microphones
- Smart Devices, e.g. Smart Meters, Key Fobs 315 MHz
- City Service Related: https://www.radioreference.com/apps/db/?ctid=4326
- WebSDR - SDR in another city over the internet
- The future: "Cognitive Radio"

SDR array on the International Space Station



Images courtesy of JPL

Thanks!

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