

Intro to Software Designed Radios (SDR)

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Background

- Former CDL Board Member
- Been building electronic and computer projects since teenager
- Extra Class Ham- WA2SFF
- Masters and PhD thesis work was on Wireless Communications
- Became interested in SDRs around 1997
- Did research, design, development and deployment of several software radio projects for work (1997-2011)
 - Published paper on one of the designs
- Author: 3 Books on Cell Phone Technology
- Prentice Hall accepted my (and co-author) book proposal on SDRs
 - Wrote alpha version in 2003-2004 but never published book
 - Work got in the way of completing the book
- Have written and taught a one day class on software radio development techniques
- Since retirement maintained interest in SDRs as a hobby

Outline

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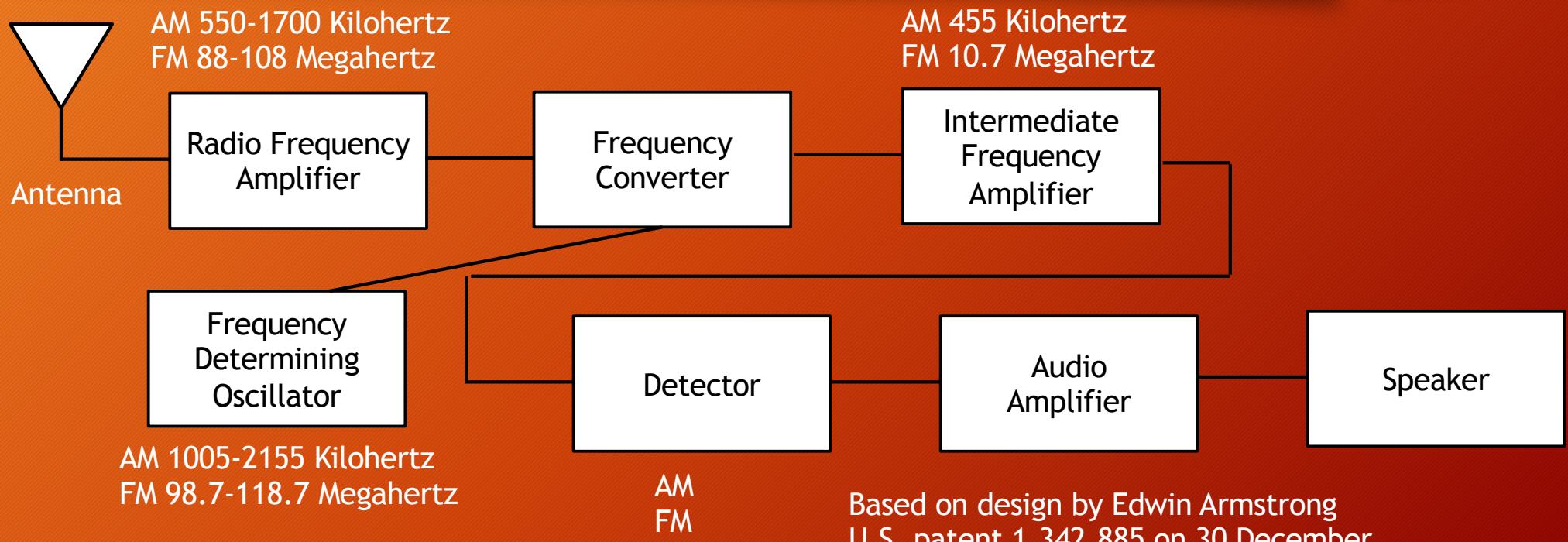
- Quick Background on "Old Designs" of radios
- Basic design of Software Radios
- Hardware for Software Radios
- Software for Software Radios
- Antennas for Software Radios
- Recommendations

Quick Background on Radio Design

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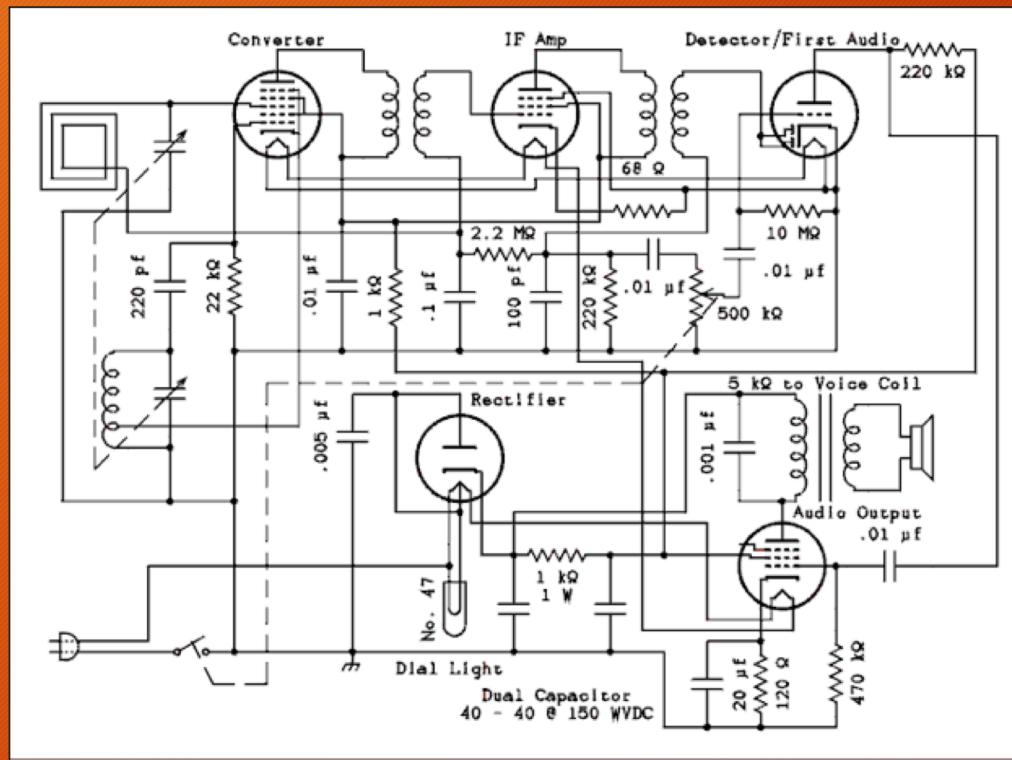
Simplified with Minimal Technical Details

Traditional Radio Design 1918-2000s

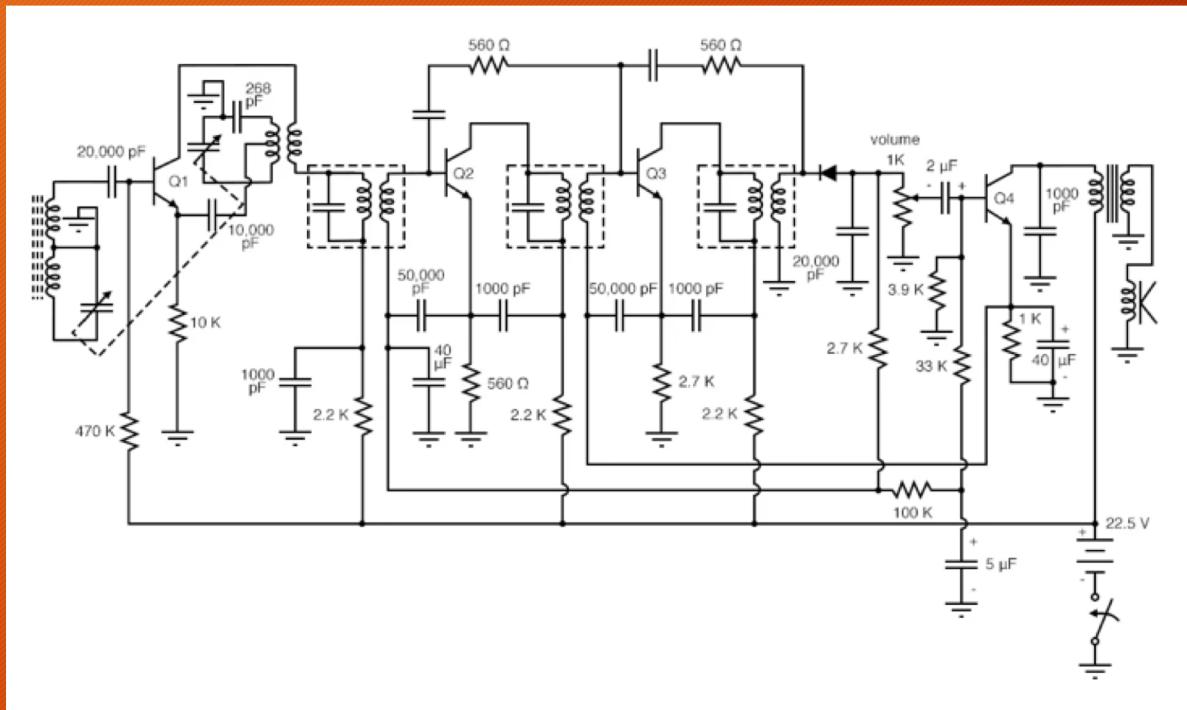


Example: 20s-60s Tube Radio

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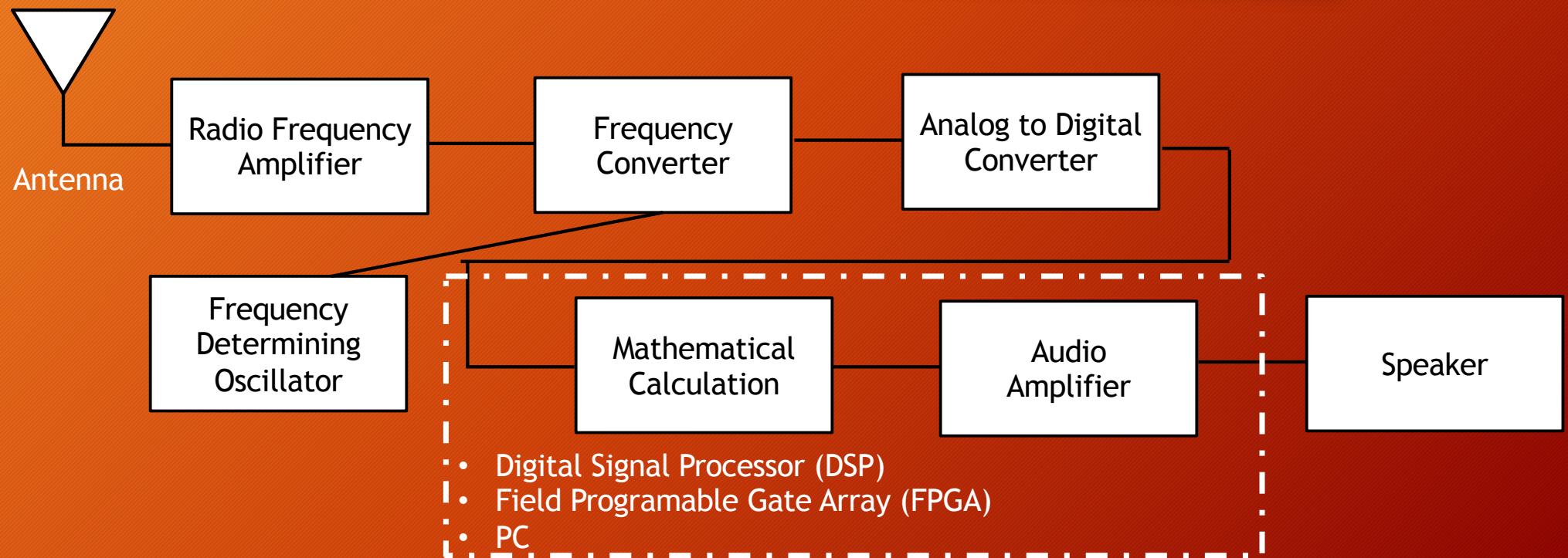
Example: Transistor Radio 50s-00s



Basic design of Software Radios

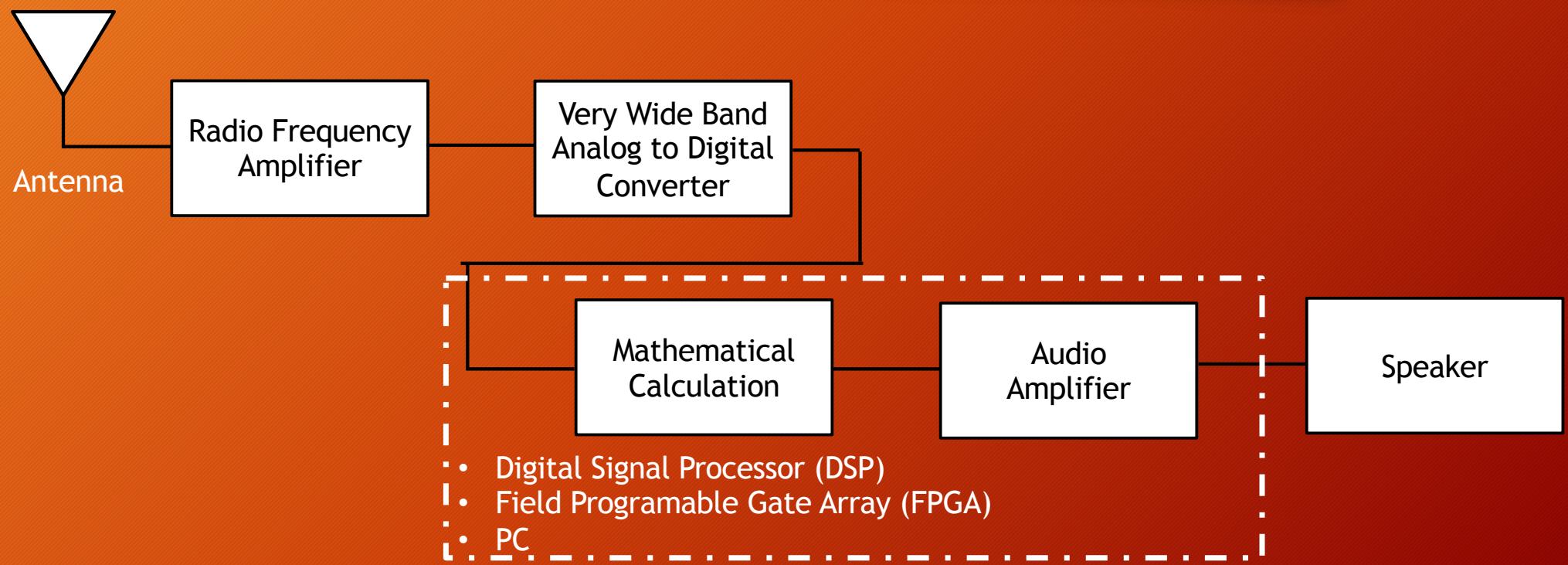
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Software Radio Design: 1990s to today



Ultimate Software Radio Design: Today for some designs

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Hardware for Software Radios

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SDR Hardware and Software

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- The common term is "Software Designed Radio" SDR
- There are multiple SDR hardware available off the shelf
 - Cost \$20 - \$100K or more
- Some are for hobbyists and some are for professionals
- I will cover the hobbyist systems and their associated software that runs on a Windows PC, Linux PC or Mac
- Each hardware system has a unique set of software
- There is no universal software that runs on all Operating Systems or supports all SDRs
- You must choose the software and operating system for the hardware you purchase

Most Common Software Radio Hardware

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- RTL-SDR
- SDRplay
- Softrock
- HackRF
- AirSpy
- BladeRF
- LimeSDR
- Flex Radio
- Universal Software Radio Peripheral (USRP) - Ettis Research

RTL-SDR

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- Based on USB Digital TV receiver for Europe
- Software developed to turn it into a general receiver
- Cheapest and most popular to get started
- Cost \$10-30 depending on where purchased
- Range: 25MHz - 1750MHz
- Optional Range: 0-30 MHz with external upconverter
- Best place to purchase: <https://www.nooelec.com>
- Can find cheaper models on ebay



SDRplay

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- Best complete device
- Easy to get working
- Designed and made in UK
- Several models \$100-300
- Range 1kHz to 2GHz
- For info and software: <https://www.sdrplay.com/>
- US vendor: www.hamradio.com



Softrock

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- Older Design for Ham radio / short wave radio use
- Receiver and Transmitter depending on model
- Windows and Linux
- Kit or assembled
- \$100-300
- I have built several of them
- Great way to get started for low power ham radio use
- Linux software fussy to build and get working
- <https://www.softrockrx.com/>



HackRF

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- Receiver and Low power Transmitter
- CDL has one
- Cost: ~\$350
- Sold by several vendors: adafruit, Amazon, others
- Range: 1 MHz to 6 GHz
- Software for receive only easy to get working
- Software for transmitting is limited and harder to get working
- <https://greatscottgadgets.com/hackrf/>



AirSpy

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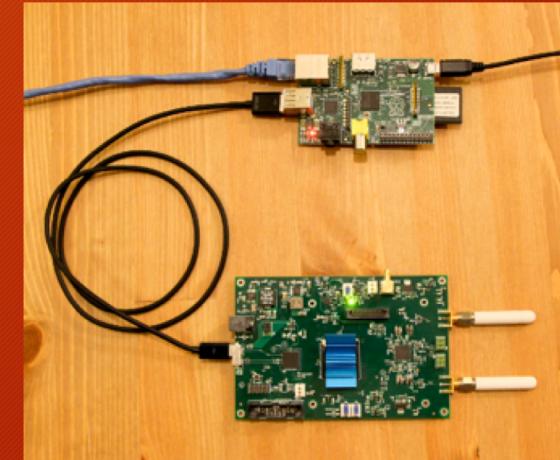
- Receiver
- Cost: \$169
- Range: 24 - 1700 MHz
- Seems to be custom design similar to RTL-SDR
- I have no experience with it
- <https://airspy.com/>



BladeRF

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- Receiver and Transmitter
- Cost: \$700-2000
- Designed for development of new capabilities
- Range: 300MHz - 3.8GHz
- I have no experience with it
- I would not recommend it unless you plan to get into SDR software development
- <https://www.nuand.com/>



LimeSDR

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- Receiver and Transmitter
- Cost: \$700-2000
- Designed for development of new capabilities
- Range: 100MHz - 3.8GHz
- I have no experience with it
- I would not recommend it unless you plan to get into SDR software development
- <https://limemicro.com/>



Flex Radio

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- The ultimate SDR for ham radio use
- Cost: \$3,000-15,000
- Can monitor two ham radio bands at once
- Uses external windows PC
- Stand-alone with built-in PC (currently out of stock - supply chain issues)
- <https://www.flexradio.com/>



Universal Software Radio Peripheral (USRP)

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- Receiver and Transmitter
- Multiple models - Cost: \$1,000-30,000+
- Designed for development of new capabilities
- Range: 10 MHz - 6 GHz, depending on model
- I have limited knowledge of it
- I would not recommend it unless you plan to get into SDR software development
- <https://www.ettus.com/>



Web SDR

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- If you don't want to buy a software radio, there are web sites that allow you to control other peoples software radios

Summary of SDR Hardware

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- I described the most common devices
- I would recommend:
 - Nooelec RTL-SDR family
 - SDRPlay
 - HackRF
- Not familiar enough with Airspy to recommend it
- Flex Radio is a dream system for hams but expensive
- Other devices are for software development rather than hobbyist use
- There are other devices but support may be limited or they may have speciality uses:
 - i.e., Bluetooth, WiFi, etc.

Software for Software Radios

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Software Radio Software

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- Each hardware had various software that supports it
- Not all software supports all hardware platforms
- You need to get the right software for your hardware
- Easiest system to get working is the SDRPlay with included/supported software
- Some software requires that it be built in C/C++ or python
- For more info:
https://wiki.radioreference.com/index.php/SDR_Software_Applications

SDRPlay Software

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- SDRUNO is the best software
- It is fully supported by the manufacturer
- It is free with the purchase of the hardware
- It does not support any other SDR platforms including SDRplay clones from Asia
- There is software for Windows, Mac, Linux, Raspberry Pi
- There is also software
 - use the SDR as a cheap spectrum analyzer
 - decode airplane beacon signal (ADS-B)
- <https://www.sdrplay.com/softwarehome/>

CubicSDR

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- Supports: Windows, Mac, Linux
- Free
- Supported Hardware:
 - SoapyRemote
 - RTL-SDR
 - AirSpy
 - SDRPlay**
 - HackRF
 - BladeRF
 - Red Pitaya
 - LimeSDR (untested)
 - others
- <https://github.com/cjcliffe/CubicSDR/releases/tag/0.2.4>

HDSDR

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- HDSDR is a freeware Software Defined Radio (SDR) program for Microsoft Windows 2000/XP/Vista/7/8/10/11
- It supports:
 - RTL-SDR
 - SDRplay hardware
 - Airspy
 - softrock
 - others
- Free to download
- Can be integrated with other Ham Radio Software
- <https://www.hdsdr.de/>

Quisk

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- Python Based
- Download from <https://pypi.org/project/quisk/>
- Quisk can control
 - lthe HiQSDR.
 - Hermes-Lite hardware.
 - SoftRock hardware for both receive and transmit.
 - SDR-IQ by RfSpace, and several other hardwares.
- Can be difficult to setup but once setup works well
- Supports LInux and Raspberry Pi
- Only non windows software for softrock SDR
- <https://james.ahlstrom.name/quisk/>

SDR Sharp (SDR#)

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- SDR# (SDRSharp) revision 1910 (2023-02-27) - The best free SDR software for Airspy and RTL-SDR dongles!
- Also supports Airspy
- Also Supports HackRF
- <https://airspy.com/download/>

Gqrx

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- A recent version of Gqrx is probably already available through the official software channels of various Linux distributions as well as Macports and Homebrew for Mac OS X.
- Not Windows
- Supports
 - Funcube Dongle Pro and Pro+
 - (USRP devices from Ettus Research)
 - Osmocom rtl-sdr via USB or TCP client
 - HackRF One by Great Scott Gadgets
 - RFspace SDR-IQ, Cloud-IQ, (SDR-IP) and (NetSDR)
 - AirSpy R2 and Mini Airspy HF+
 - LimeSDR
 - PlutoSDR
 - (SDRplay)
 - Others
- <https://gqrx.dk/>
- download <https://github.com/gqrx-sdr/gqrx/releases>

- GNURadio is a development system to support building receivers and transmitters for various software radios
- Use graphical user interface to build block diagrams of radios
- GUI code is complied into Python
- Python code calls blocks that were written and complied from C/C++
- If some communication system is not supported, the end user can write there own code to support it.
- More for developers rather than hobbyists but some pre-built code is available
- Supports a wide range of hardware
- <https://www.gnuradio.org/>

Matlab SDR software

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- **Matlab**
- is a mathematical language that supports computer simulation by Mathworks
 - Expensive and requires yearly subscription
- A home Perpetual version of Matlab is available for \$149
<https://www.mathworks.com/products/matlab-home.html>
- Mathworks has written a "free" extensive book on SDRs that uses Matlab code and the RTL-SDR to learn about SDRs
- <https://www.mathworks.com/academia/books/software-defined-radio-using-matlab-simulink-and-the-rtl-sdr-barlee.html>
- **GNU Octave**
- is an open source language compatible with Matlab code
- <https://octave.org/>
- Powerful mathematics-oriented syntax with built-in 2D/3D plotting and visualization tools
- Free software, runs on GNU/Linux, macOS, BSD, and Microsoft Windows
- Drop-in compatible with many Matlab scripts

Antennas for Software Radios

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Antennas

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- The best radio in the world will not give best performance with a poor antenna
- Since SDRs are often wide band, a wide band antenna is needed
- There are a few options depending on where the antenna is placed
- The best performance will be with an outdoor antenna as high as possible
- For local use and/or to get started, indoor antennas will work OK
- In addition to the antenna you will need
 - a mounting arrangement,
 - connectors for antenna and receiver
 - coax cable

In Door Antennas

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- The typical indoor antenna is a collapsible whip antenna.
 - range 50-1000 MHz
 - keep it short for higher frequencies
 - lengthen it for low frequencies
 - some SDRs include it
 - <https://www.amazon.com/outstanding-Telescopic-Antenna-Section-Connector/dp/B07D32NNKF>



Outdoor Antennas

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- For VHF/UHF use a discone antenna is the best wideband antenna
 - typically covers 25-1300 MHz
 - <https://www.hamradio.com/detail.cfm?pid=H0-007179>
- For shortwave use I recommend a G5RV antenna
 - covers 2-30 MHz
 - typically 100 feet long
 - <https://www.hamradio.com/detail.cfm?pid=H0-001039>



Recommendations

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- I have used: softrock, sdrplay, rtl-sdr, my own designs
- I have watched a friend use his Flex Radio
- While I did not do development on USRP, work colleagues took a week long course on it before starting development
- I have designed and developed software radios using DSPs and dedicated Professional SDR platforms
- To get started, as simply as possible I recommend buying an SDRplay radio from www.hamradio.com (the US distributor of the product)
- Next best approach is RTL-SDR from www.nooelec.com
- If you want to get more technical get the free Mathworks book and code and either buy a home license or use Octave

QUESTIONS?

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