SOFTWARE DEFINED RADIOS

GETTING STARTED WITH SDR

WØTLM SMALL GROUP SESSION

LOREN ANDERSON KEØHZ

OUTLINE

- Software Defined Radio (SDR) background
  - SDR Hardware
  - How SDRs work (very basic)
- SDR software applications & demo
  - SDR# (SDR Sharp) with RTLSDR
  - Gnuradio with RTLSDR
  - OpenWebRX with RTLSDR
  - SDRuno with SDRplay

CREDIT WHERE CREDIT IS DUE

- Numerous slides with permission from Rocky Mountain Ham University
  - Practical SDR With OpenWebRX, Ben Matthews KC2VJW, April 9, 2022
  - GNURadio, Willem Schreüder, ACØKQ , April 9, 2022

SDR HARDWARE – EASY MODE

- Commercial Transceiver
- All self contained - No Software Required
- The IC-7300 is an example of a Direct Conversion SDR

IC-7300 HF/50MHz TRANSCEIVER

Features

Specifications
Options
Product Gallery

Product Brochure
Instruction Manual
Hi-Resolution Image
Firmware/Software

The Innovative HF Transceiver

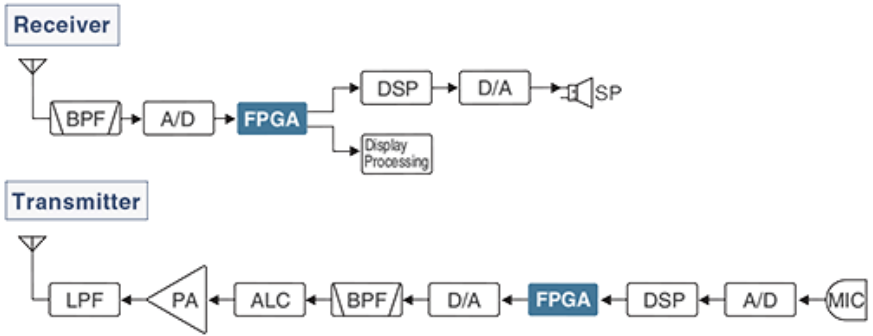
New technology is changing the way receivers are being designed and the IC-7300 is an industry first as an RF, Direct Sampling System is being used in an entry level HF radio. The ability to digitize RF before various receiver stages reduces the inherent noise that is generated in the different IF stages of a radio. We feel the performance of the '7300 will far exceed your expectations for a radio considered entry level.

Output Power:	100W (25W AM)
RX Frequencies:	0.030-74.800
Receiver Type:	Direct sampling

RF Direct Sampling System

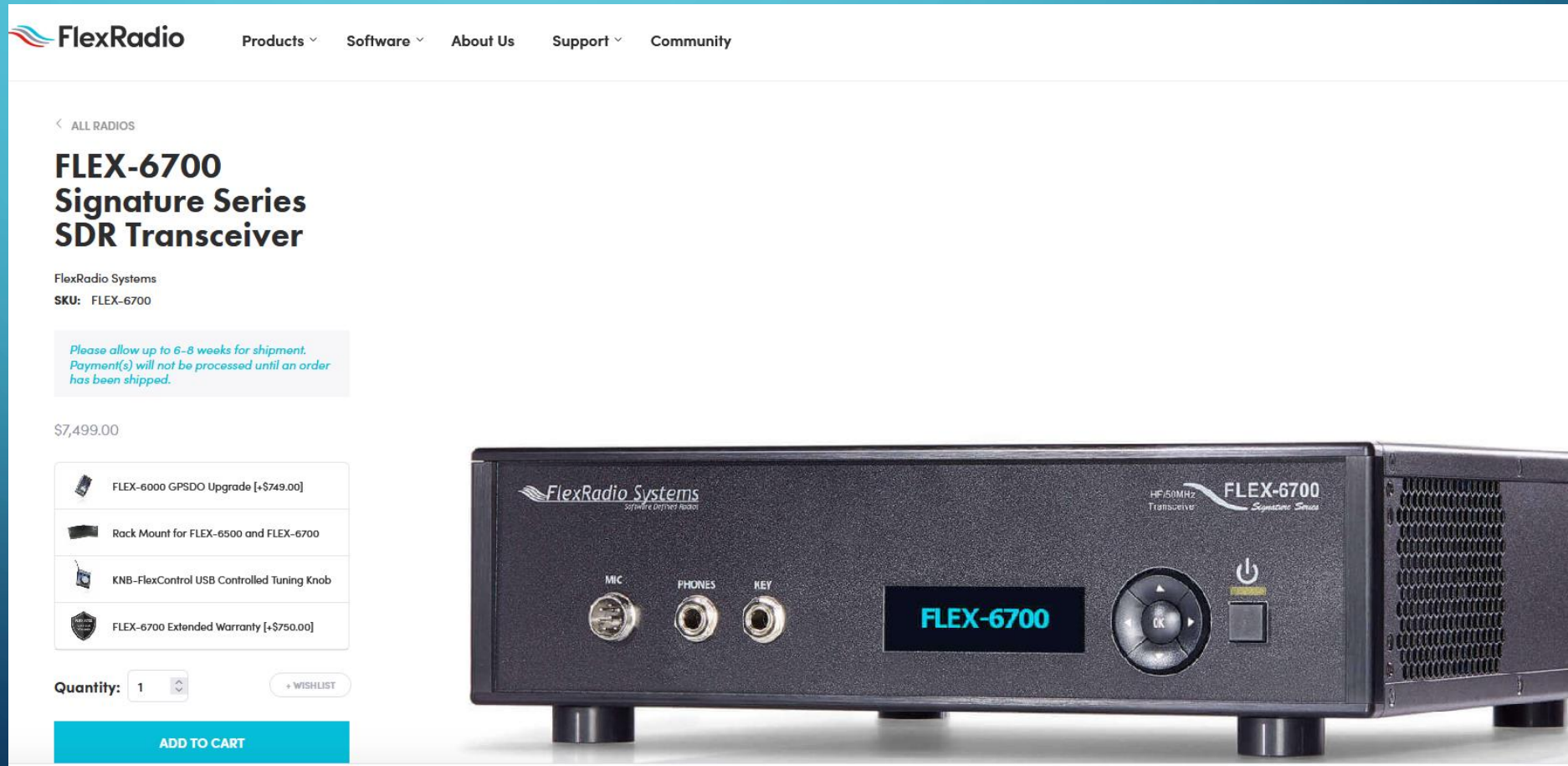
The IC-7300 employs an RF direct sampling system, where RF signals are directly converted to digital data. Then processed in the FPGA (Field-Programmable Gate Array), making it possible to simplify the circuit construction as well as reduce noise that can mask weak signals.

The new "IP+" improves the 3rd order intercept point (IP3) performance improving the ability to copy a weak signal that is adjacent to either a strong interfering signal. In this process, A/D converter is optimized to reduce or eliminate signal distortion.



SDR HARDWARE – SLIGHTLY HARDER MODE

- Commercial Transceiver
- External Computer required but S/W included



SDR – HARDER MODE

- Range from very economical to $$$$
  - RTL-SDR
  - SDRPlay
  - HackRF
  - BladeRF
  - KrakenSDR
  - Airspy
  - … Tons to chose from

OTHER HARDWARE CONSIDERATIONS

- Antenna system as you would any other radio
- External filters can be a good idea
- Good quality cables (Computers/USB can be RF noisy)
- Faster computers are better, but it really depends on how much bandwidth you need

BRIEF BACKGROUND ON SDR

- Utilize Digital Signal Processing (DSP) often performed by Field-Programmable Gate Array (FPGA)
- Nyquist Sampling Theorem
  - To digitize a waveform without aliasing, sampling must be at least TWICE the frequency of the waveform. (Aliasing: seeing a periodic event of one frequency occurring at a different frequency because of the ratio between sampling frequency and the actual behavior.)
- Sampling is performed with an analog to digital converter (ADC) with a sampling rate capability at least twice the input frequency.
  - Direct Conversion did not become practical until the sampling speeds in the ADC increased significantly.
  - In early days the signal processing was done at IF frequencies

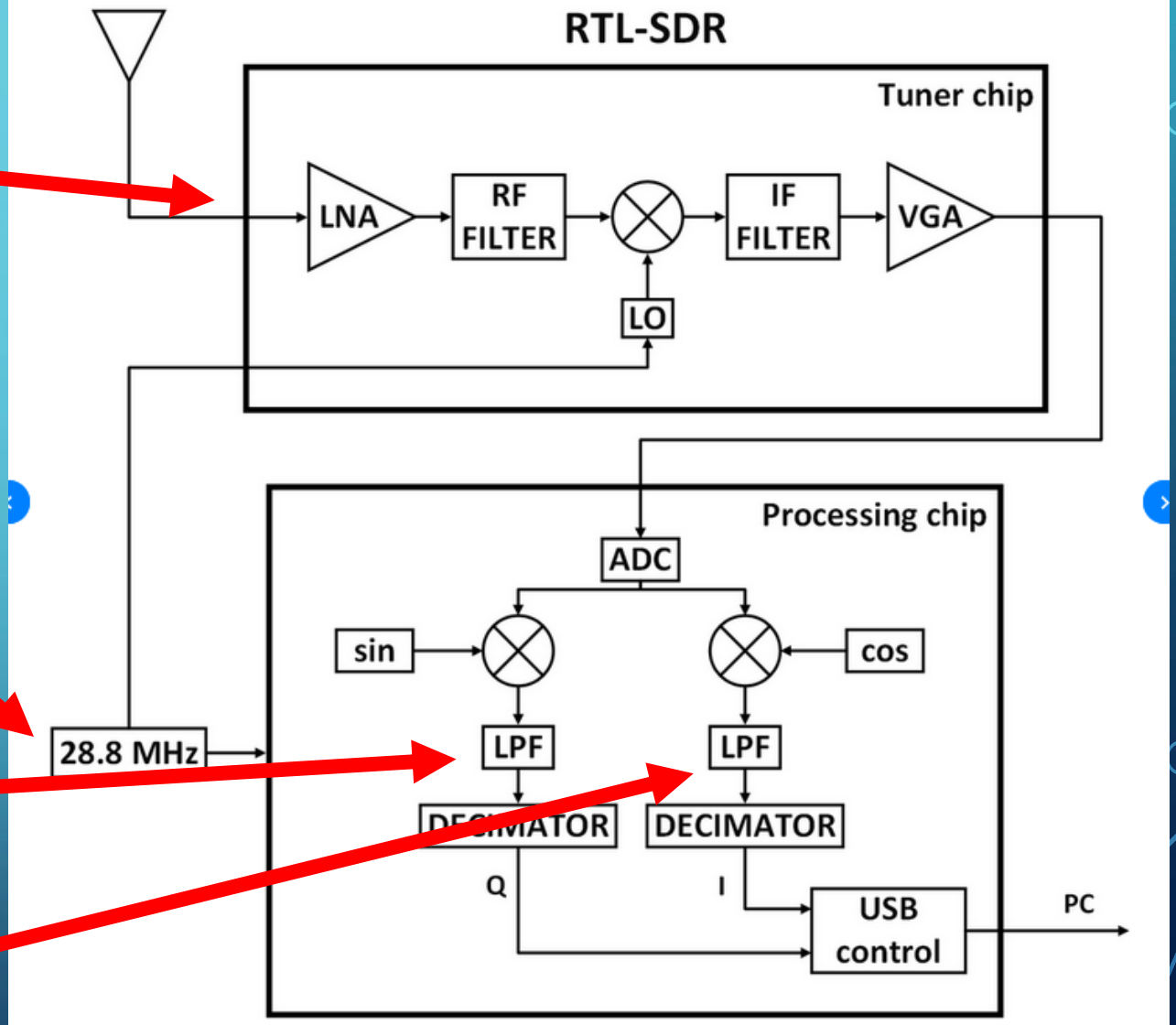
RTL-SDR BLOCK DIAGRAM

Front-end

Local Oscillator
(not a DC SDR)

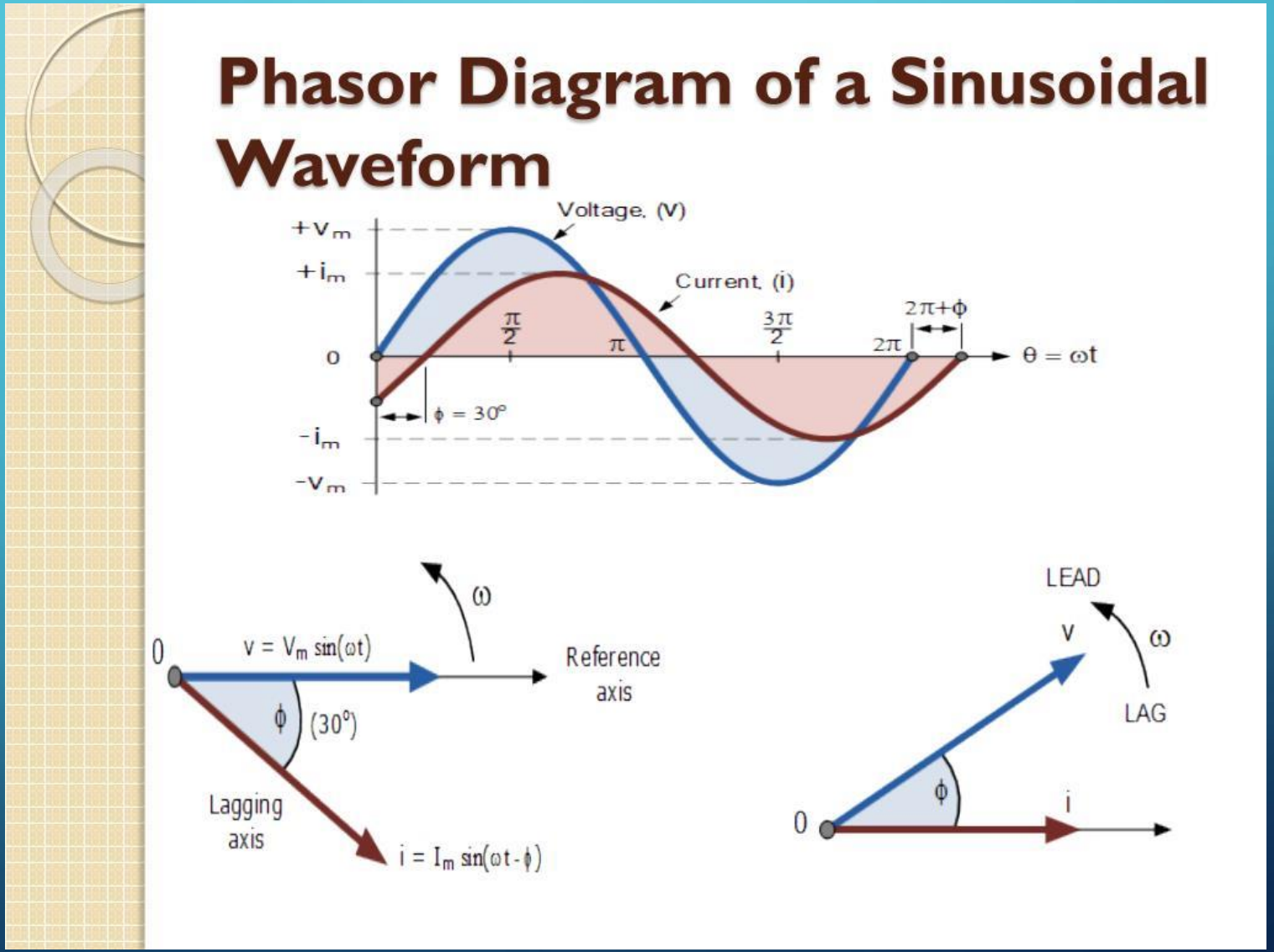
“Q” signal (quadrature)
Q is phase shifted +90° with respect to “I”

“I” signal (in-phase)



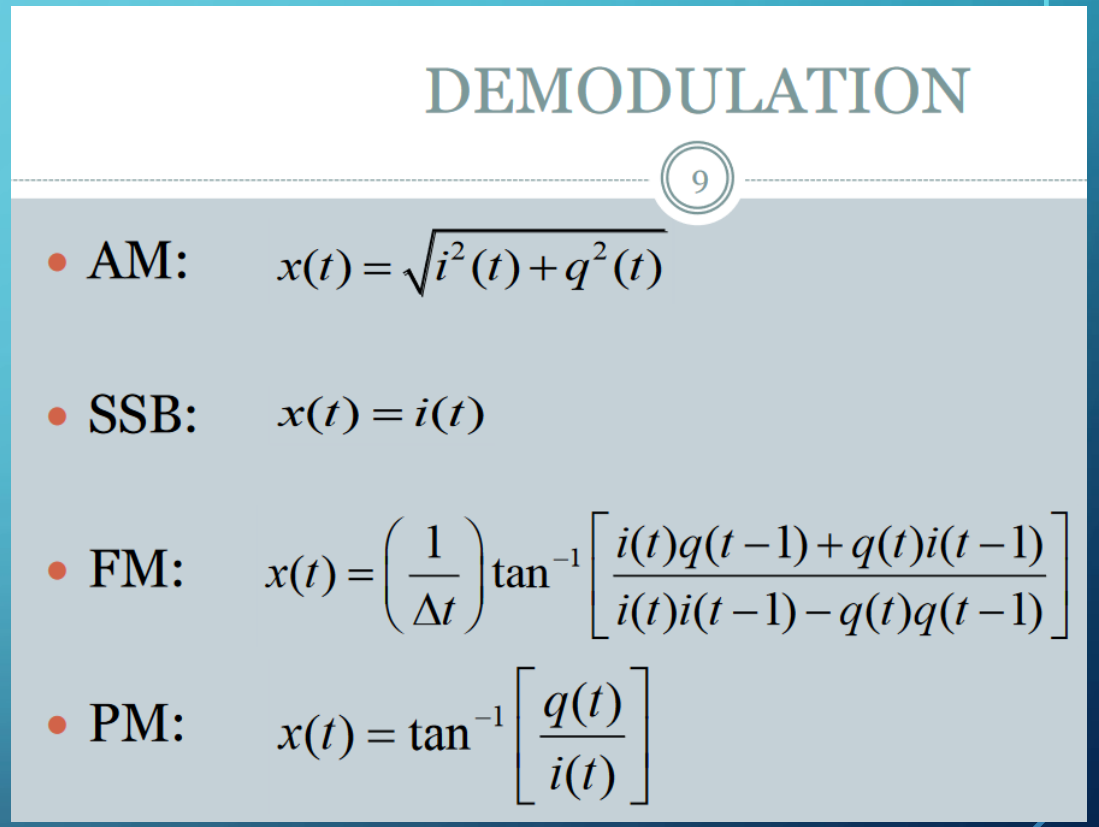
Block diagram of the RTL-SDR.

REPRESENTING WAVEFORMS AS PHASORS



WHAT ARE THE I/Q SIGNALS?

- In-phase (I)/Quadrature (Q) simply means that the input signal by definition is the I signal and the Q signal is shifted 90 degrees. I = Cosine/Q = Sine function
- It doesn't matter if the input signal's phase is varying. The Q signal is always shifted 90 degrees from the input signal.
- Demodulation equations easily handled by DSP
- Let's do some basic high school trigonometry. AM demodulation is simply the Pythagorean Theorem



I/Q SIGNALS WITH NO AM MODULATION

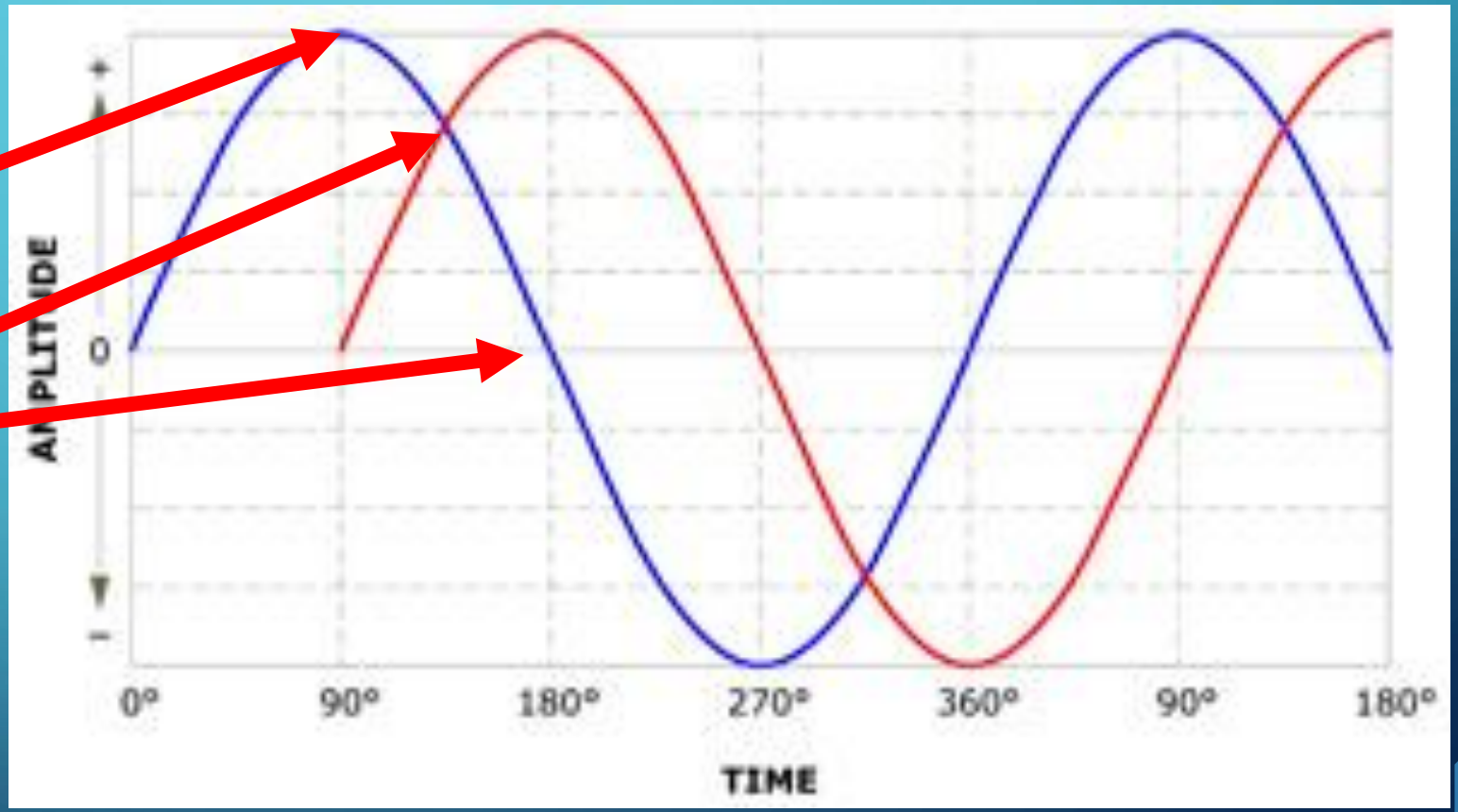
$X = \sqrt{(I^2 + Q^2)}$

90°: I = 1, Q = 0, X = 1

135°: I = .707, Q = .707, X = 1

180°: I = 0, Q = 1, X = 1

X is always 1. No signal variation!



SDR# (SDR SHARP)

SDR# DOWNLOAD

HTTPS://AIRSPY.COM/DOWNLOAD

https://airspy.com/download/

Financial Secret... | AmateurRadio.com • ... | Equatorial Adapter for ... | Hoseline | Solar Conditions and ... | LISIRD | ScienceAlert: The Best ... | Helio4Cast | PD board - Agile boar... | v21.5.1 Unanet — Das...

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SDR Software Download

Global Radio Guide Winter 2021-2022

During times of emergency and crisis, radio hobbyists worldwide turn on their radios and tune to the shortwave radio spectrum for context, perspective, and insight into what is happening around the globe. As tensions heat up in the world's hotspots, you can follow these events on the radio, but you need an accurate and comprehensive radio guide to know where and when to tune in to hear the action. If you are using our SDRs to navigate the spectrum, you will definitely like the **Global Radio Guide** from our friends at **Teak Publishing**.

Software Defined Radio Package (Change log)

Download

This package contains:

- SDR# (SDRSharp) **revision 1855** (2022-03-26) – The best free SDR software for Airspy and RTL-SDR dongles!
- Airspy drivers
- HackRF driver
- USRP driver
- RTL-SDR driver (manual installation script)

If you are looking for the last unskinned SDR# build, check here. For the latest SDR# build with collapsible panels check here. For the latest dotnet 4.x build (1784) check here. These packages also contain the legacy hardware support tools. The last dotnet 5.x build (1831) can be found here.

SDR# SDK for Plugin Developers

Download

This package contains a zero-setup Visual Studio 2022 solution with a few plugin examples from the main software distribution. These examples illustrate the Graphical and DSP APIs in many scenarios along with full

SDR#

Install Driver

- Installs SRDLL.dll

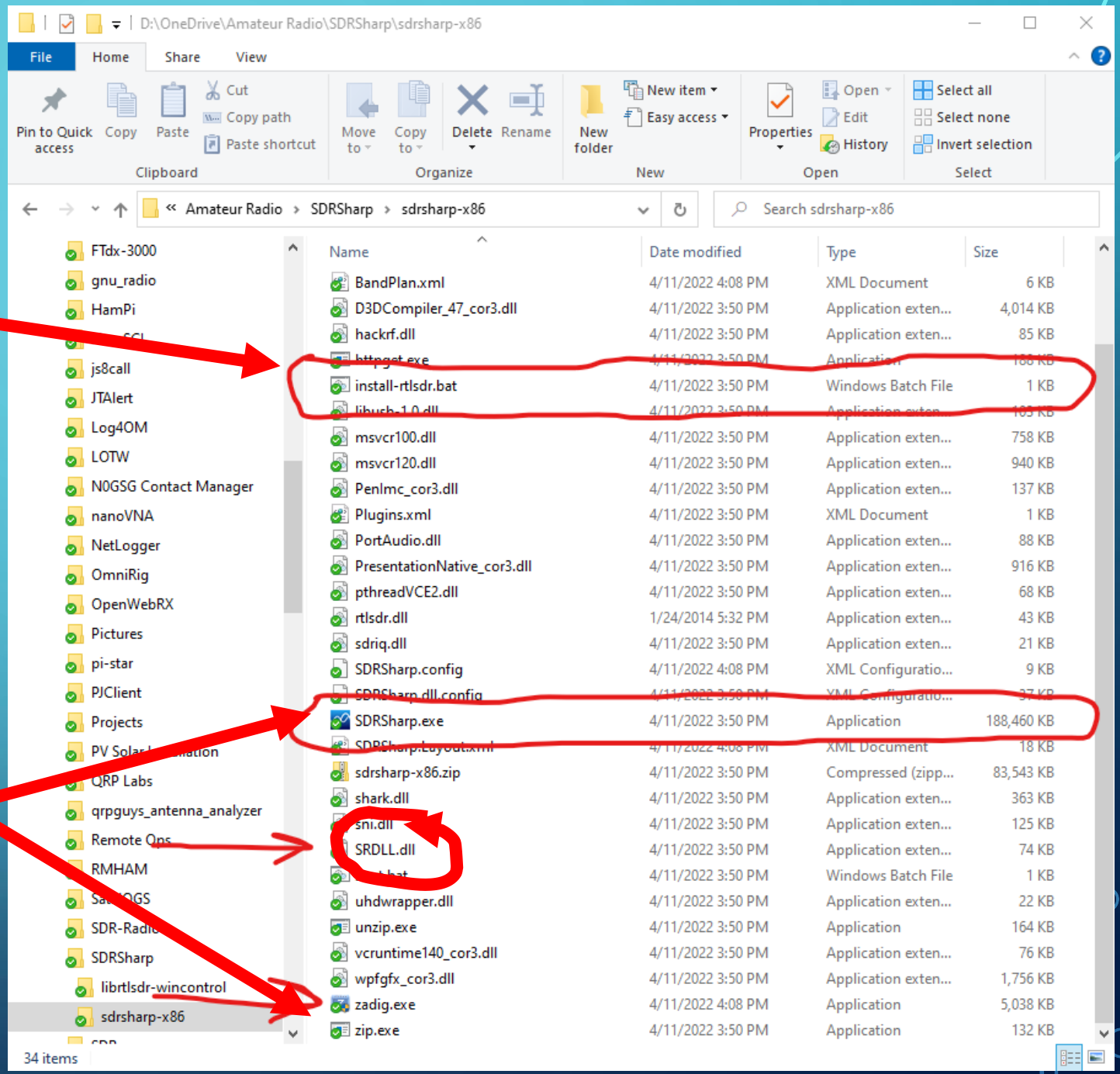
Insert RTLSDR USB

- Windows installs driver that SDR# can't use

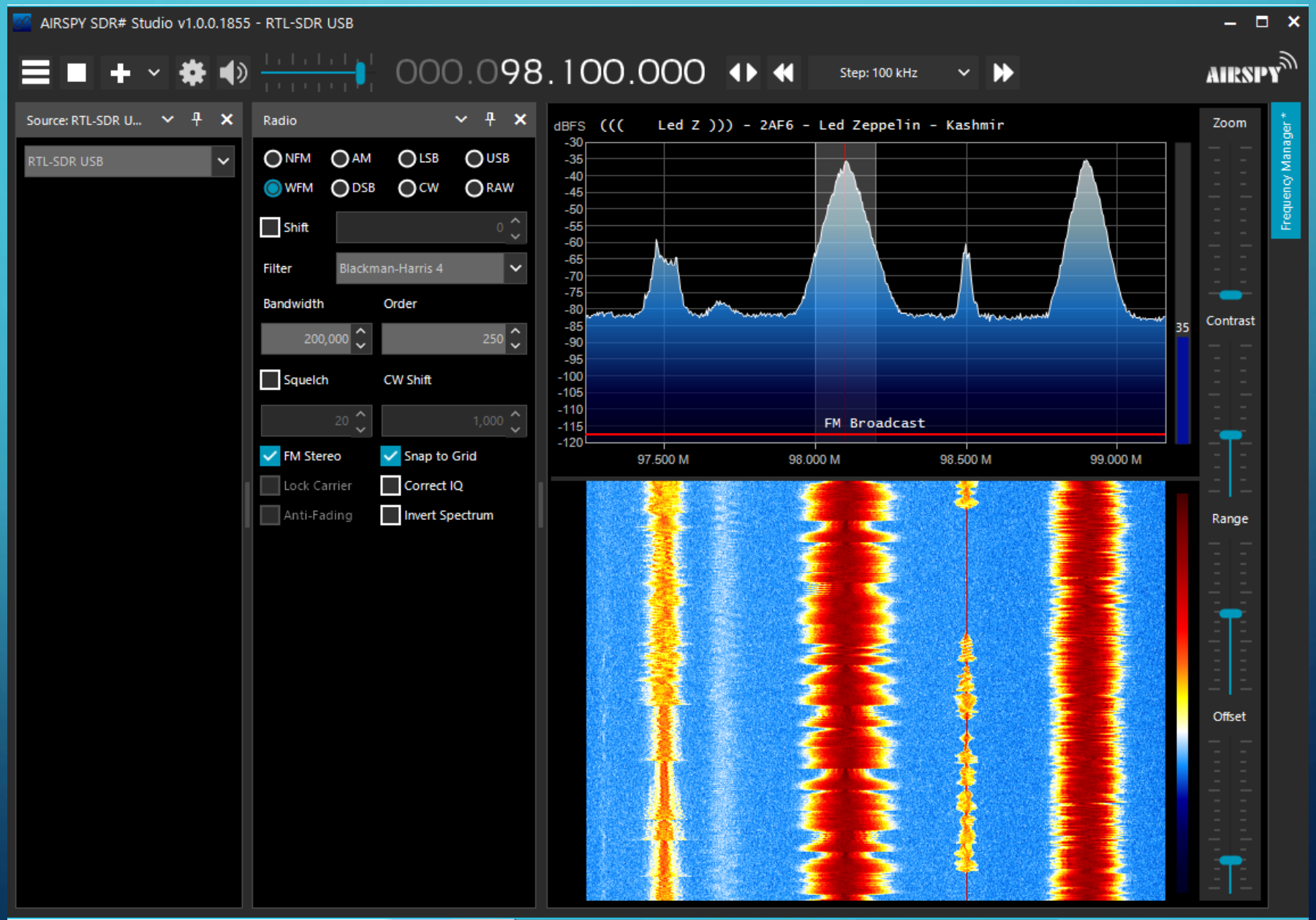
Run zadig.exe

- Replace driver
- See YouTube video

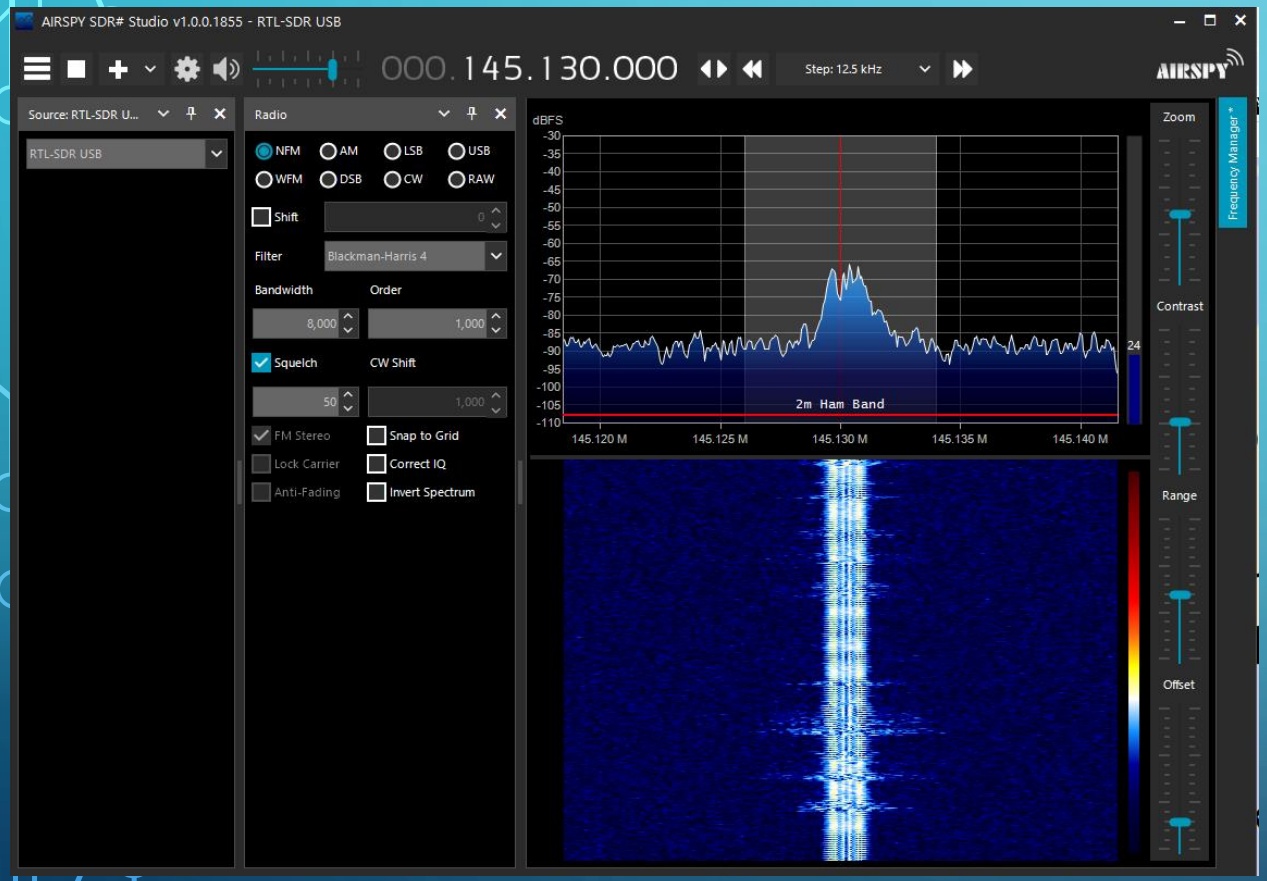
Run SDR#

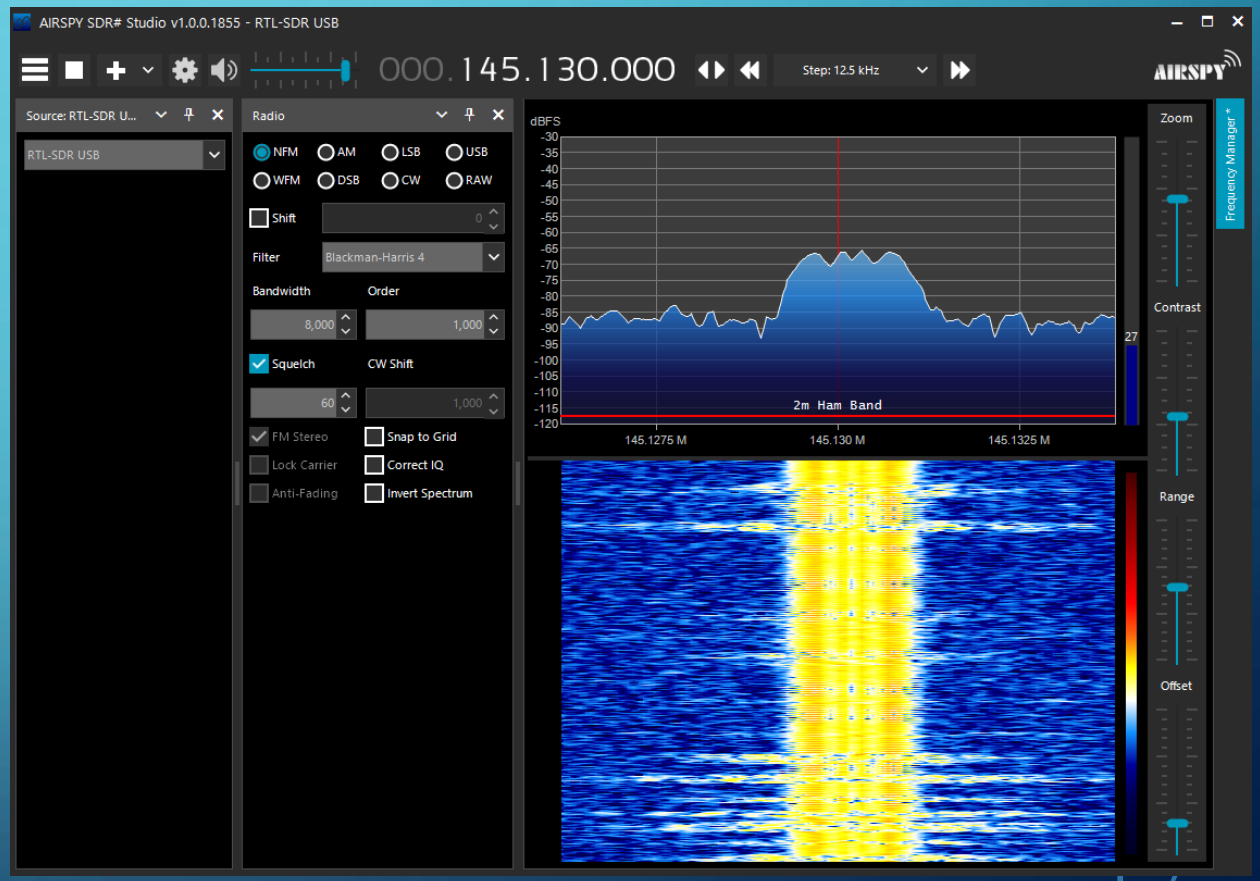


SDR# FM BROADCAST RECEIVER



RTL-SDR WITH SDR# (SDRSHARP) (WINDOWS)





GNURADIO

GNURADIO

- Software Radio Ecosystem
- Open-source (FREE!) software development toolkit that provides signal processing blocks to implement software radios
- Written in Python
  - Can be ported to microcontrollers avoiding need for a heavy operating system (e.g., Windows)

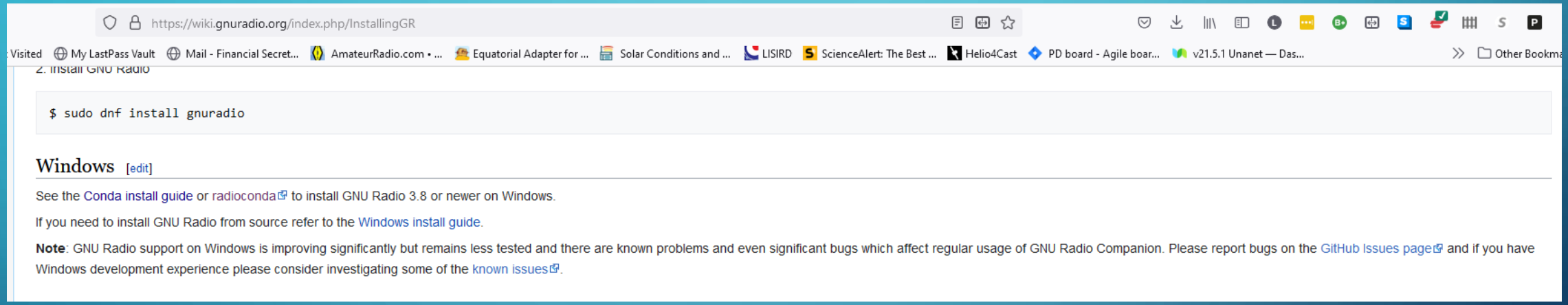
  https://www.gnuradio.org/
- GNU Radio Companion – GUI to manipulate signal processing blocks

  Using GNU Radio Companion Part 1 YouTube video
- Thanks to Willem Schreuder, AC0KQ & Rocky Mountain Ham University

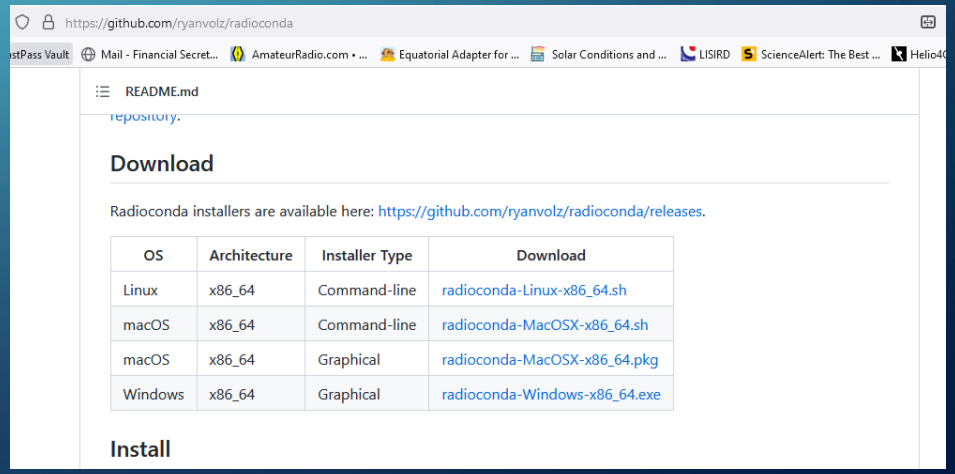
  https://www.rmham.org/wp-content/uploads/2022/04/gnuradio.pdf

GNURADIO INSTALLATION

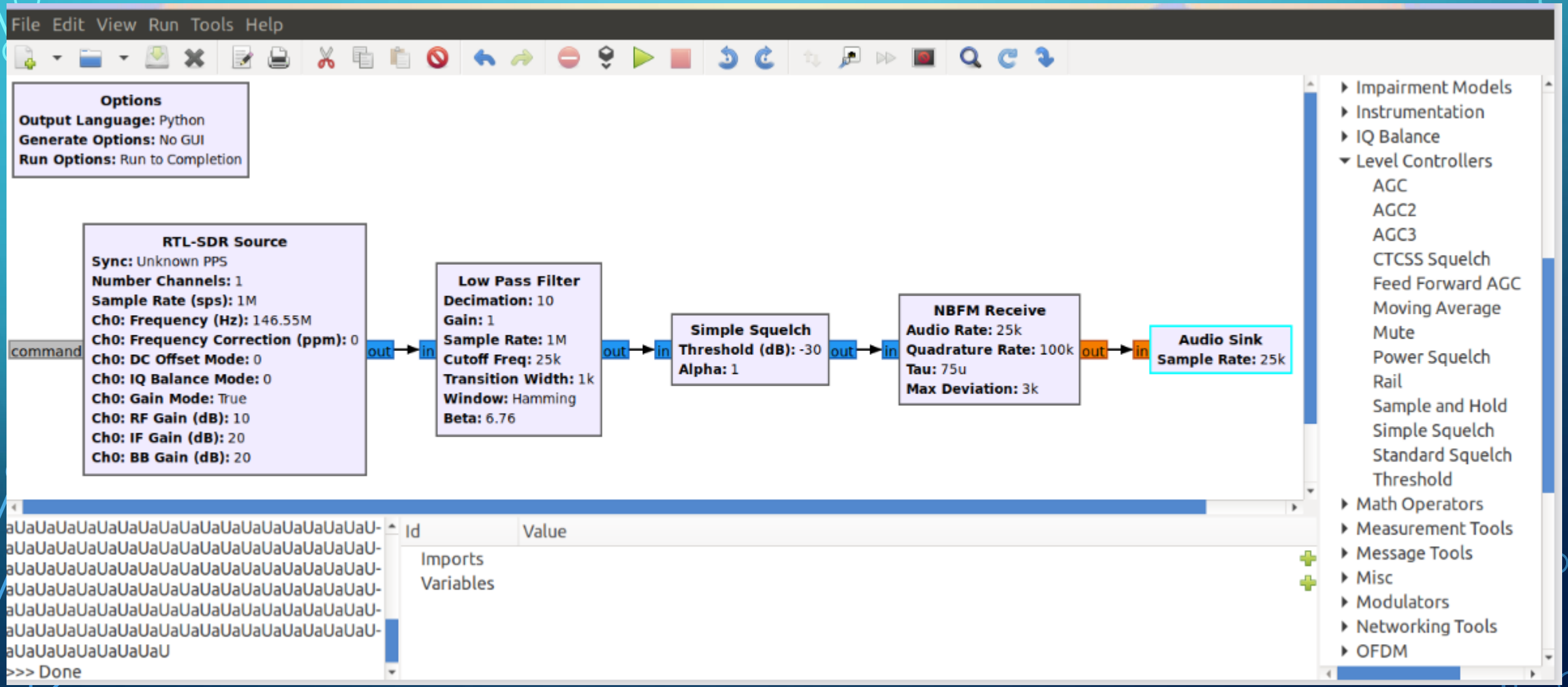
- From https://gnuradio.org Getting Started
  - Select Installing GNU Radio



- https://github.com/ryanvolz/radioconda



GNURADIO COMPANION – 2M NBFM RECEIVER



OPENWEBRX

THANKS TO BEN MATTHEWS, KC2VJW, ROCKY MOUNTAIN HAM UNIVERSITY

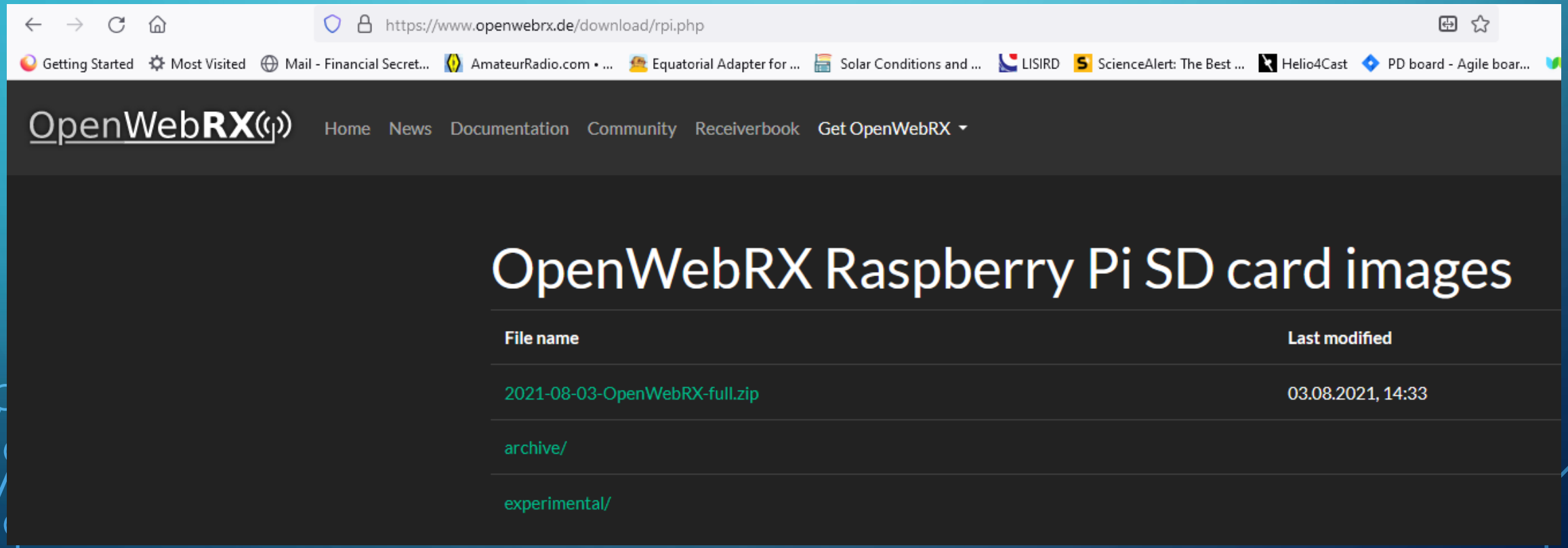
OPENWEBRX

- Linux based but you don't need to be a Linux expert
- Runs on Raspberry Pi (3 or 4)
  - More powerful computers required when more users are accessing via web server
- Interface via webserver
  - Access from any computer with a web browser (laptop (Windows), notepad)
  - May be opened to wider web beyond your home network
- Lots of decoders available
- Thanks to Ben Matthews, KC2VJW & Rocky Mountain Ham University

- Detailed installation instructions for Raspberry Pi available at https://www.rmham.org/wp-content/uploads/2022/04/PracticalSDR.pdf

OPENWEBRX SETUP

- OpenWebRX image loaded on SD card

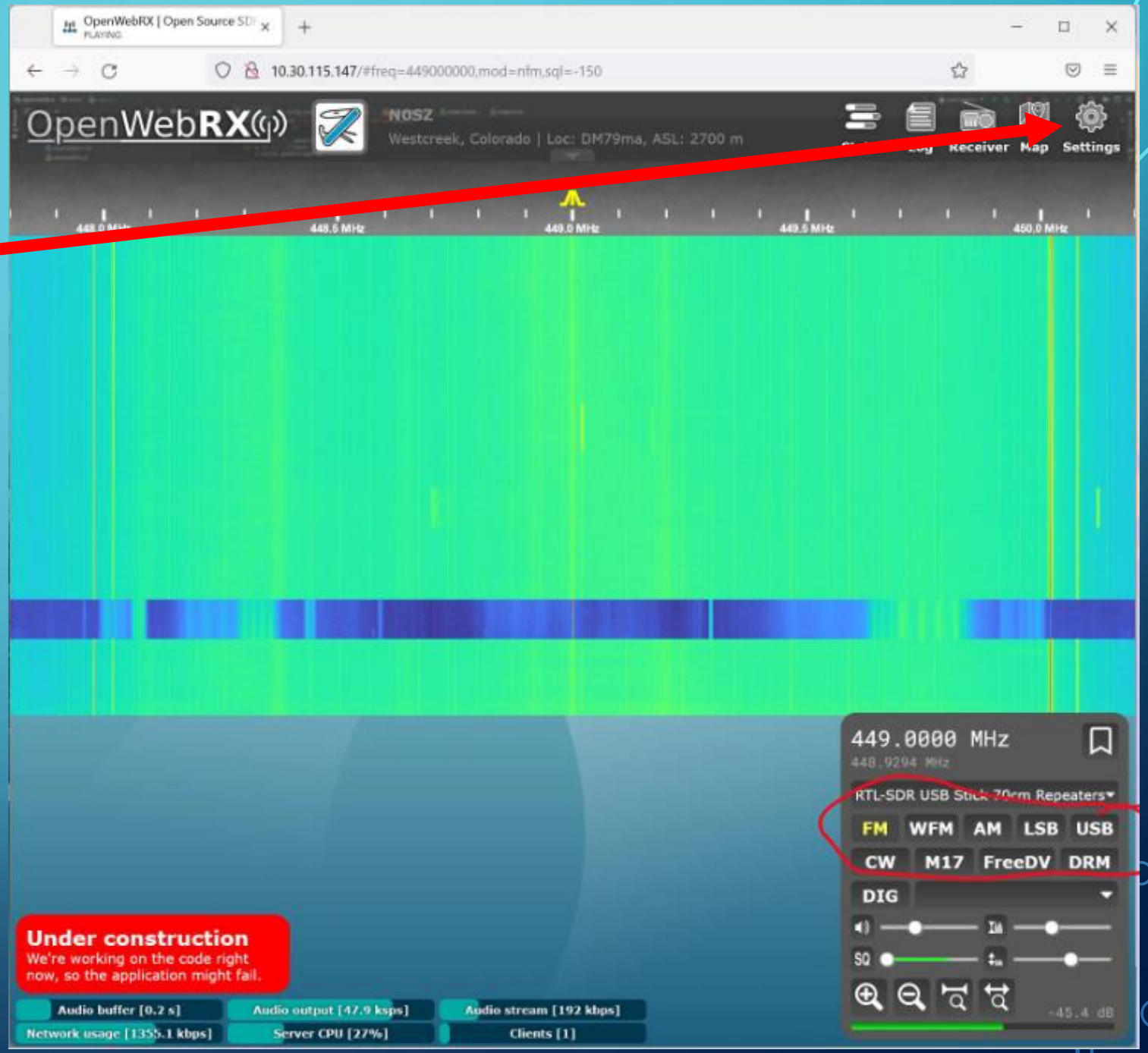


OPENWEBRX SETUP CONTINUED

- This is a broad brush, not detailed instructions
- It may be useful to run your RPi at first with monitor, keyboard & mouse
  - Update & Upgrade RPi
  - Run raspi-config to enable SSH and reset your password
  - Setup an OpenWebRX admin account to enable management of OpenWebRX application https://github.com/jketterl/openwebrx/wiki/User-Management
  - Run ifconfig to determine IP address of RPi
- If you have comm program (e.g., Putty) for Windows computer you can now run the RPi "headless"
  - Disconnect monitor, keyboard & mouse

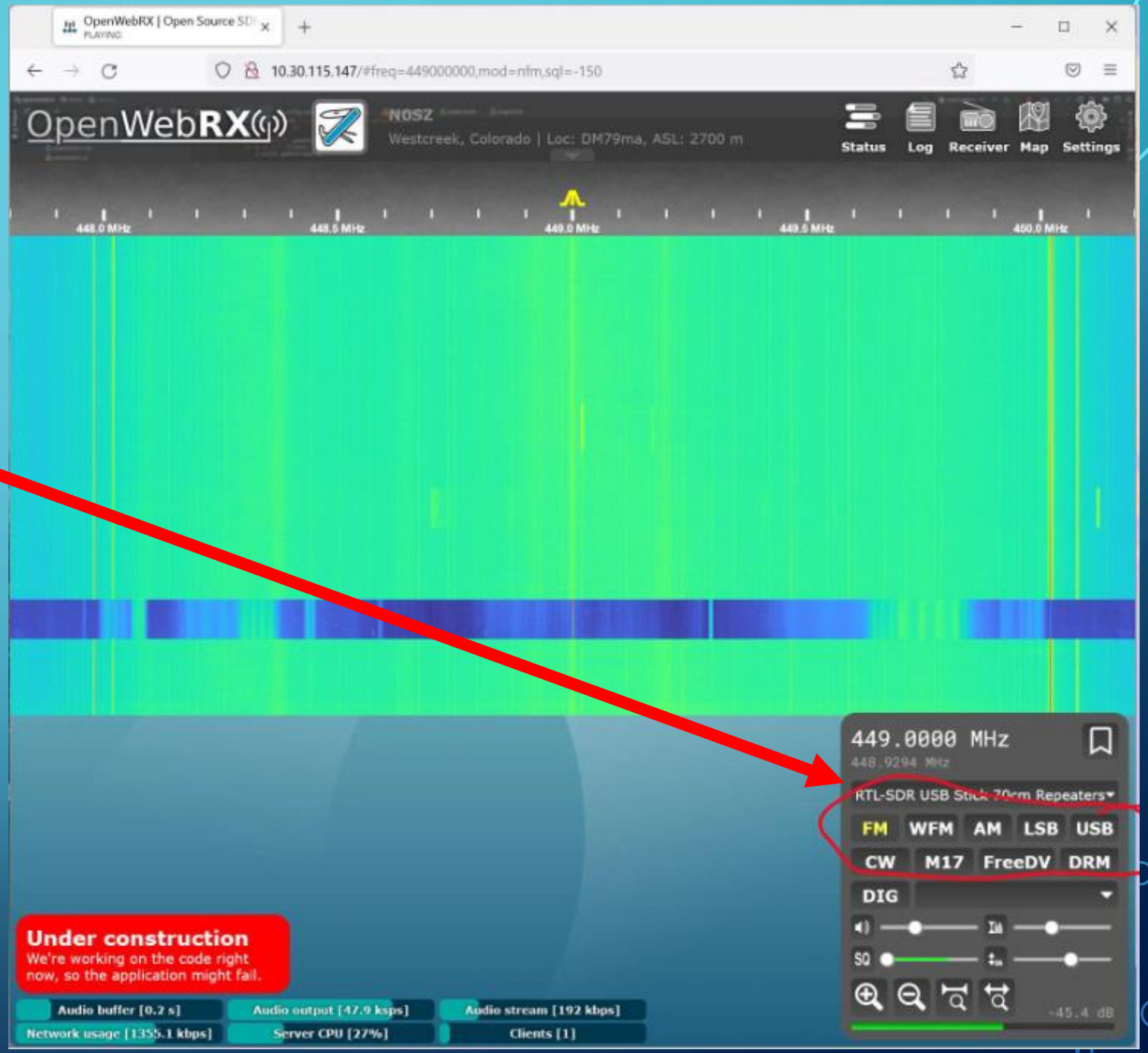
WEB APPLICATION

- Set up custom receiver
  - Select Center Frequency
  - Sample Rate
  - Starting Frequency
  - RF Gain



WEB APPLICATION

- Select the receiver you just set up
- Select mode



OPENWEBRX DEMO

SDRUNO WITH FTDX-3000

SDR PLAY FOR FTDX-3000 PANADAPTER

- Instead of antenna providing signal source relying on transceiver to provide signal
- Using SDRuno software to do rig control
- Rig has RF and IF outputs (protected from transmitted signal)
  - RF output has wider bandwidth than IF so entire band can be seen
- SDRuno software for Windows
- Omnirig for rig control from SDRuno
  - I seldom touch the tuning knob
  - Tuning with mouse click on signal and fine tuning with mouse wheel
- Adaptable to any rig with CAT interface
- Logging software (Log4OM) automatically receives frequency and mode information and does QRZ lookup when callsign entered

SDRUNO WITH FTDX-3000 RF OUTPUT