

Introduction to Software Defined Radio (SDR) - A Hands-on Course

Class 3: Exploring SDR with the RTL-SDR, Part 1

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Charles J. Lord, PE
President, Consultant, Trainer
Blue Ridge Advanced Design and Automation

Presented by:

DesignNews

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Blue Ridge Advanced Design and Automation
Asheville, North Carolina



This Week's Agenda

9/25 Intro to SDR

9/26 RF and Radio Basics

9/27 Exploring SDR with the RTL-SDR, Part 1

9/28 Exploring SDR with the RTL-SDR, Part 2

9/29 Commercial SDR Designs

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Our Kit

What is the RTL-SDR?

RTL-SDR is a very cheap software defined radio that uses a DVB-T TV tuner dongle based on the RTL2832U chipset. With the combined efforts of Antti Palosaari, Eric Fry and Osmocom it was found that the signal I/Q data could be accessed directly, which allowed the DVB-T TV tuner to be converted into a wideband software defined radio via a new software driver.

Essentially, this means that a cheap \$20 TV tuner USB dongle with the RTL2832U chip can be used as a computer based radio scanner. This sort of scanner capability would have cost hundreds or even thousands of dollars just a few years ago. The RTL-SDR is also often referred to as RTL2832U, DVB-T SDR, RTL dongle or the “\$20 Software Defined Radio”.

-from <https://www.rtl-sdr.com/>

Adafruit 1497 Kit



Includes the “nano” package RTL2832U along with the R820T2 tuner, giving us approximately a 24-1730 Mhz range of tuning. We can go up or down from this range with an appropriate up or down converter.

We will not use the remote or disk today

The software that we will be using today should work with most any of the RTL2832-based dongles or adapters.

Although an inexpensive ‘hobbyist’ kit, we can use this to learn the principles used in commercial SDR development. On Friday we will look at more sophisticated hardware including transceivers.

The Antenna

- The antenna in the kit is approximately 6” long and has a magnet in the base to attach to a ferrous surface.

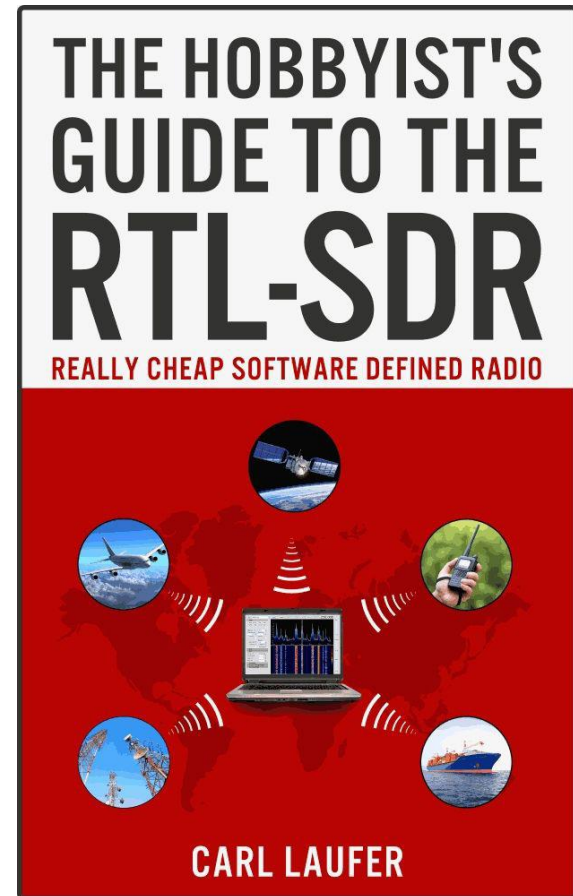
- Question 1 – two parts:
 - What approximate frequency is the antenna best at?
 - How big a piece of metal should it be attached to (ideally)?

A Good Book to Have

The Hobbyist's Guide To The RTL-SDR: Really Cheap Software Defined Radio

A Guide to the RTL-SDR and Cheap Software
Defined Radio by the Authors of the
rtl-sdr.com Blog

<http://amzn.to/2ys9qdc>



The Book

- Along with the many great examples of projects including tracking planes and boats and exploring the wavelengths, the author starts off by directing us to the website of Dr Wickert at University of Colorado College of Engineering and Applied Science, where he teaches a class based on the RTL-SDR and provides all of his notes and labs (!)

<http://eas.uccs.edu/~mwickert/ece4670/>

ECE 4670 Communications Lab

Updated 08:45 PM on Saturday, April 29, 2017

News for 03-29-2017

The Lab 6 ZIP package is update to fix an error in probability of bit error calculation function. 1 Jupyter notebook is included to verify that the error counting function is working properly.

A short discussion of working with the ADS PN generator and configuring it for 10-bit (length 1023 codes). Under Lab2.

A short pdf document on brining ADS plot data in Jupyter notebook now posted.

You will start using Keysight ADS during LAB 1. An brief ADS tutorial is available in the *Agilent ADS Tutorial and Lab Projects* center tab. When you get using the ADS Workspace for lab 3 you may need to install the component library

Catalog Course Description

Laboratory experiments demonstrating material taught in ECE 4625/5625. Use is made of spectrum analysis to study baseband signals and signal processors. Topics include AM, FM, PM, sampling, TDM, digital modulation, errors, and complete communication systems.
Corequisite: ECE 4625
Offered: Spring

Course Materials - Lab Handouts

Course syllabus as of 10:31 AM on Tuesday, January 17, 2017.

Lab 1 as of 05:13 PM on Sunday, January 04, 2015.

Lab 2 as of 08:34 PM on Sunday, February 02, 2014. www.mbed.org, [PN_seq.cpp](#). **ADS 10 bit PN.**

Lab 3 as of 10:40 PM on Monday, February 17, 2014.

Lab 4 as of 11:13 PM on Monday, February 24, 2014.

Lab 5 as of 02:24 PM on Tuesday, March 11, 2014.

Lab 6 as of 09:04 AM on Wednesday, May 21, 2014. The lab 6 **MATLAB zip package** as of 11:03 PM on Sunday, April 20, 2014 and the **Python zip package** as of 08:42 PM on Saturday, April 29, 2017.

Office Hours

T 3:05 to 4:00 PM and 7:05 to 8:00 PM
M/W 11:00 AM to 12:00 PM, or by appointment.
Office EN 292,
Phone 255-3500,
mwickert@uccs.edu.

Learning Python

Python Basics (beta) a tutorial written in IPython Notebook

Link to *Anaconda*. This is the scientific Python I recommend.

An IDE I recommend is *Pycharm Community Edition*.

[Buy Now](#)

The class is taught using SDR#, Python, and MATLAB. He also provides links to his tutorials on python and Matlab.

The first thing to download from the site is the Lab 4 document and the lab zip files (one each for python and Matlab).

I found his links to the version of python and an excellent IDE to be very helpful!

First, we want to get SDR#



Home > Download

Core tools

Windows SDR Software Package ([Change log](#))

Download

Contains:

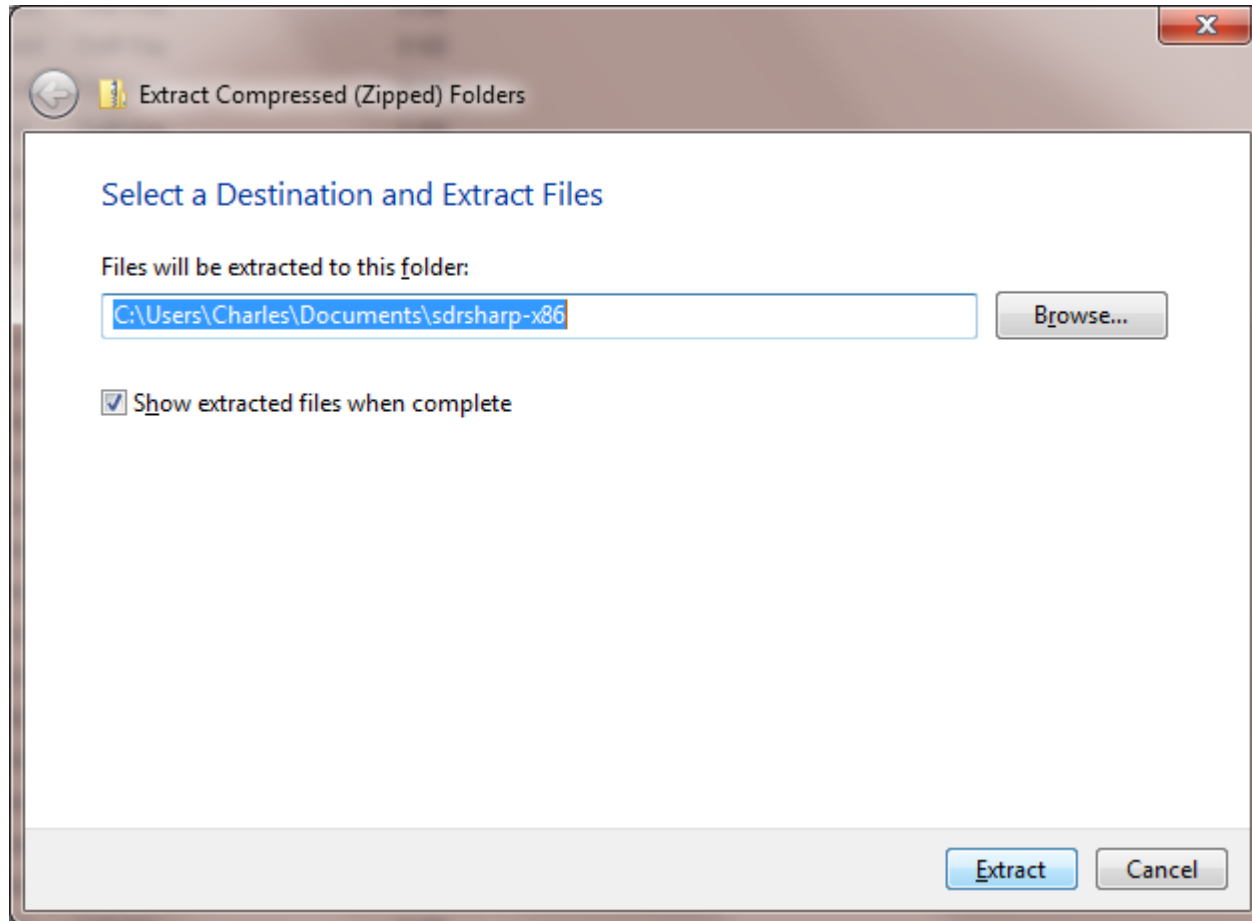
- SDR# x86 rev 1583
- Airspy Calibration Tool
- ADSB Spy rev 37 – High Performance ADSB Decoder (Requires firmware 1.0.0-rc7 or better)
- Spectrum Spy – Spectrum Analyzer
- Astro Spy – Radio Astronomy Utility for Hydrogen Line Spectroscopy
- SPY Server – Multi-client SDR Server with DDC

SDR# For Windows x64

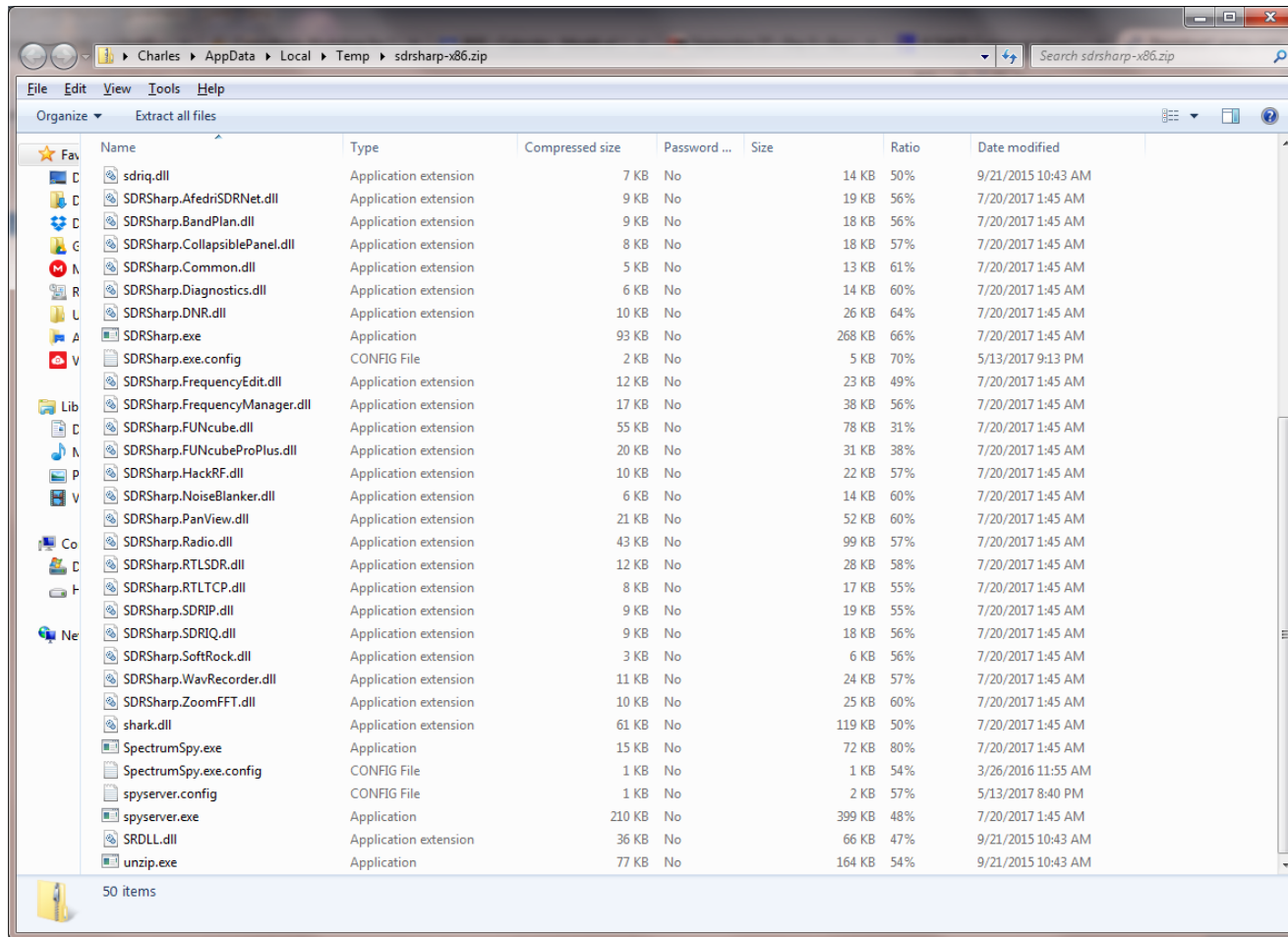
Download

This build can be used with 64bit Intel/AMD CPU's. Note that some very old plugins may not work as expected – if at all.

Unzip to a Handy Place

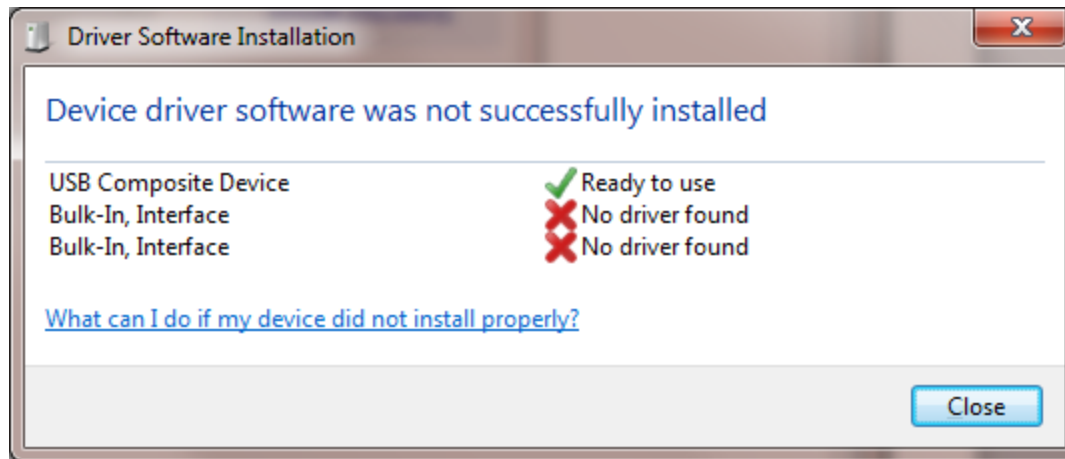


LOTS of plugins



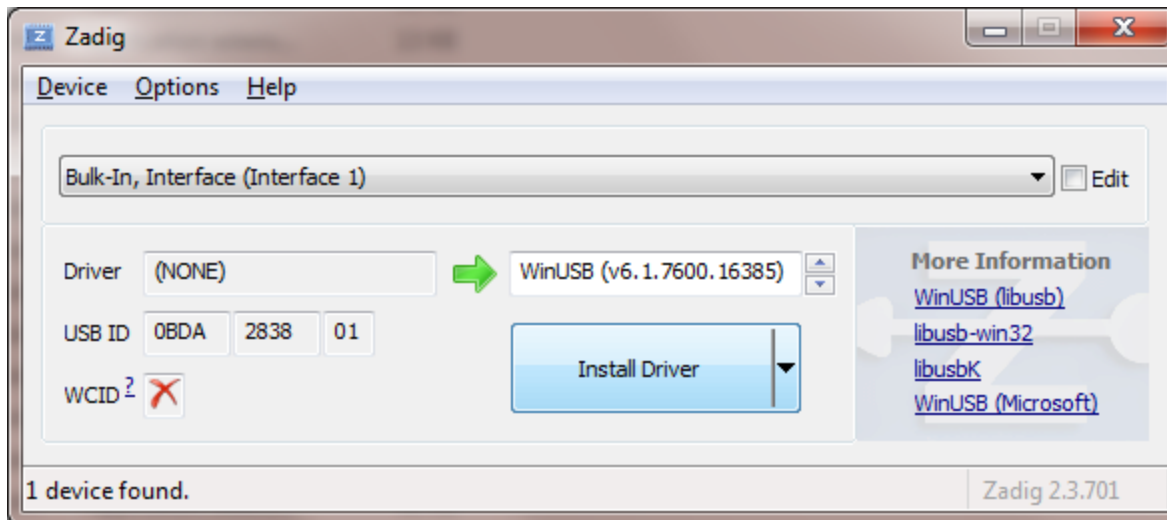
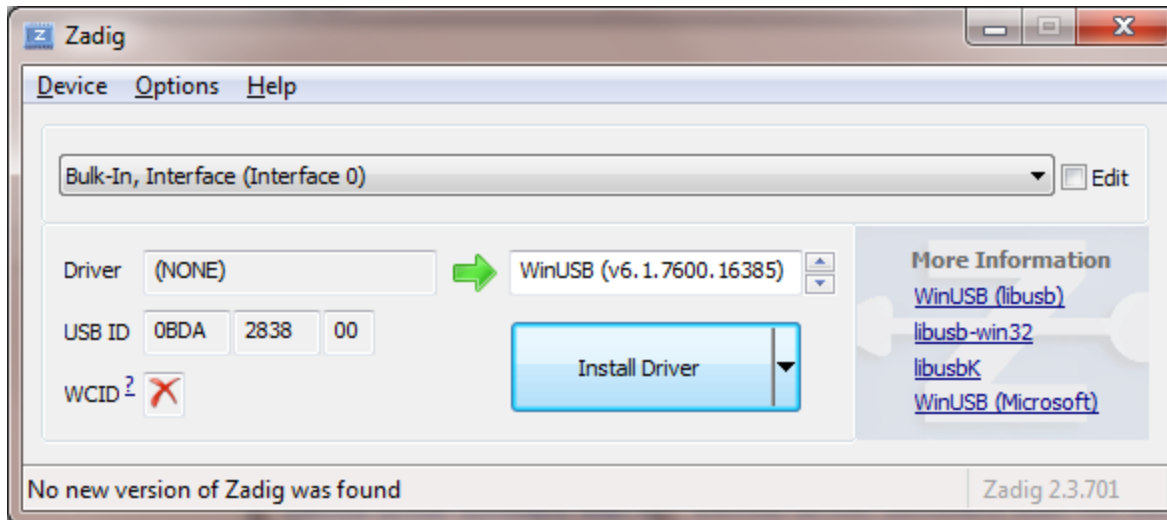
Name	Type	Compressed size	Password ...	Size	Ratio	Date modified
sdriq.dll	Application extension	7 KB	No	14 KB	50%	9/21/2015 10:43 AM
SDRSharp.AfedriSDRNet.dll	Application extension	9 KB	No	19 KB	56%	7/20/2017 1:45 AM
SDRSharp.BandPlan.dll	Application extension	9 KB	No	18 KB	56%	7/20/2017 1:45 AM
SDRSharp.CollapsiblePanel.dll	Application extension	8 KB	No	18 KB	57%	7/20/2017 1:45 AM
SDRSharp.Common.dll	Application extension	5 KB	No	13 KB	61%	7/20/2017 1:45 AM
SDRSharp.Diagnostics.dll	Application extension	6 KB	No	14 KB	60%	7/20/2017 1:45 AM
SDRSharp.DNR.dll	Application extension	10 KB	No	26 KB	64%	7/20/2017 1:45 AM
SDRSharp.exe	Application	93 KB	No	268 KB	66%	7/20/2017 1:45 AM
SDRSharp.exe.config	CONFIG File	2 KB	No	5 KB	70%	5/13/2017 9:13 PM
SDRSharp.FrequencyEdit.dll	Application extension	12 KB	No	23 KB	49%	7/20/2017 1:45 AM
SDRSharp.FrequencyManager.dll	Application extension	17 KB	No	38 KB	56%	7/20/2017 1:45 AM
SDRSharp.FUNCube.dll	Application extension	55 KB	No	78 KB	31%	7/20/2017 1:45 AM
SDRSharp.FUNCubeProPlus.dll	Application extension	20 KB	No	31 KB	38%	7/20/2017 1:45 AM
SDRSharp.HackRF.dll	Application extension	10 KB	No	22 KB	57%	7/20/2017 1:45 AM
SDRSharp.NoiseBlanker.dll	Application extension	6 KB	No	14 KB	60%	7/20/2017 1:45 AM
SDRSharp.PanView.dll	Application extension	21 KB	No	52 KB	60%	7/20/2017 1:45 AM
SDRSharp.Radio.dll	Application extension	43 KB	No	99 KB	57%	7/20/2017 1:45 AM
SDRSharp.RTLSDR.dll	Application extension	12 KB	No	28 KB	58%	7/20/2017 1:45 AM
SDRSharp.RTLTCP.dll	Application extension	8 KB	No	17 KB	55%	7/20/2017 1:45 AM
SDRSharp.SDRIP.dll	Application extension	9 KB	No	19 KB	55%	7/20/2017 1:45 AM
SDRSharp.SDRIQ.dll	Application extension	9 KB	No	18 KB	56%	7/20/2017 1:45 AM
SDRSharp.SoftRock.dll	Application extension	3 KB	No	6 KB	56%	7/20/2017 1:45 AM
SDRSharp.WavRecorder.dll	Application extension	11 KB	No	24 KB	57%	7/20/2017 1:45 AM
SDRSharp.ZoomFFT.dll	Application extension	10 KB	No	25 KB	60%	7/20/2017 1:45 AM
shark.dll	Application extension	61 KB	No	119 KB	50%	7/20/2017 1:45 AM
SpectrumSpy.exe	Application	15 KB	No	72 KB	80%	7/20/2017 1:45 AM
SpectrumSpy.exe.config	CONFIG File	1 KB	No	1 KB	54%	3/26/2016 11:55 AM
spyserver.config	CONFIG File	1 KB	No	2 KB	57%	5/13/2017 8:40 PM
spyserver.exe	Application	210 KB	No	399 KB	48%	7/20/2017 1:45 AM
SRDLL.dll	Application extension	36 KB	No	66 KB	47%	9/21/2015 10:43 AM
unzip.exe	Application	77 KB	No	164 KB	54%	9/21/2015 10:43 AM

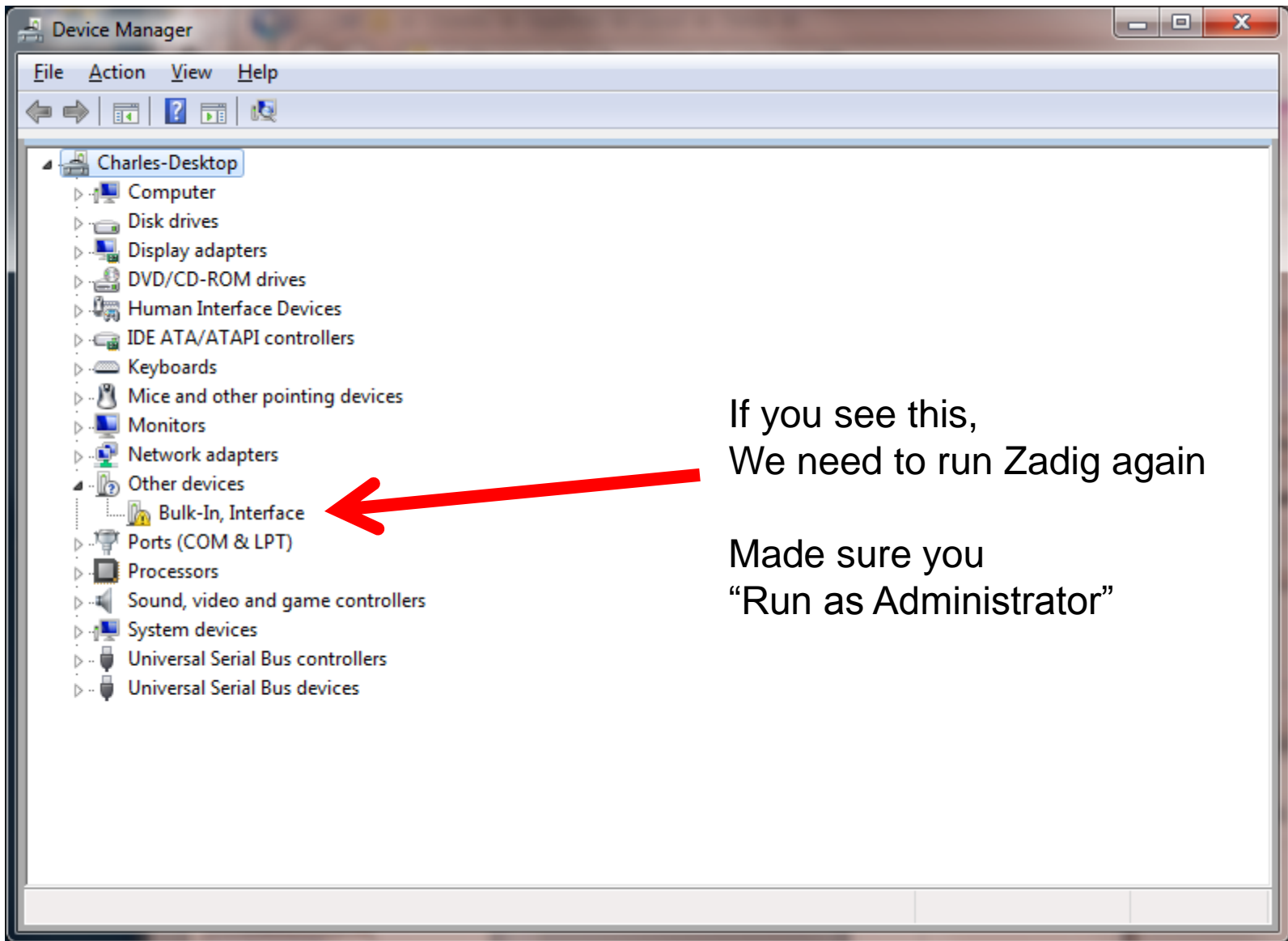
We need Drivers! Or you may have the wrong drivers...



Question 2 – Why might we need to replace a driver?

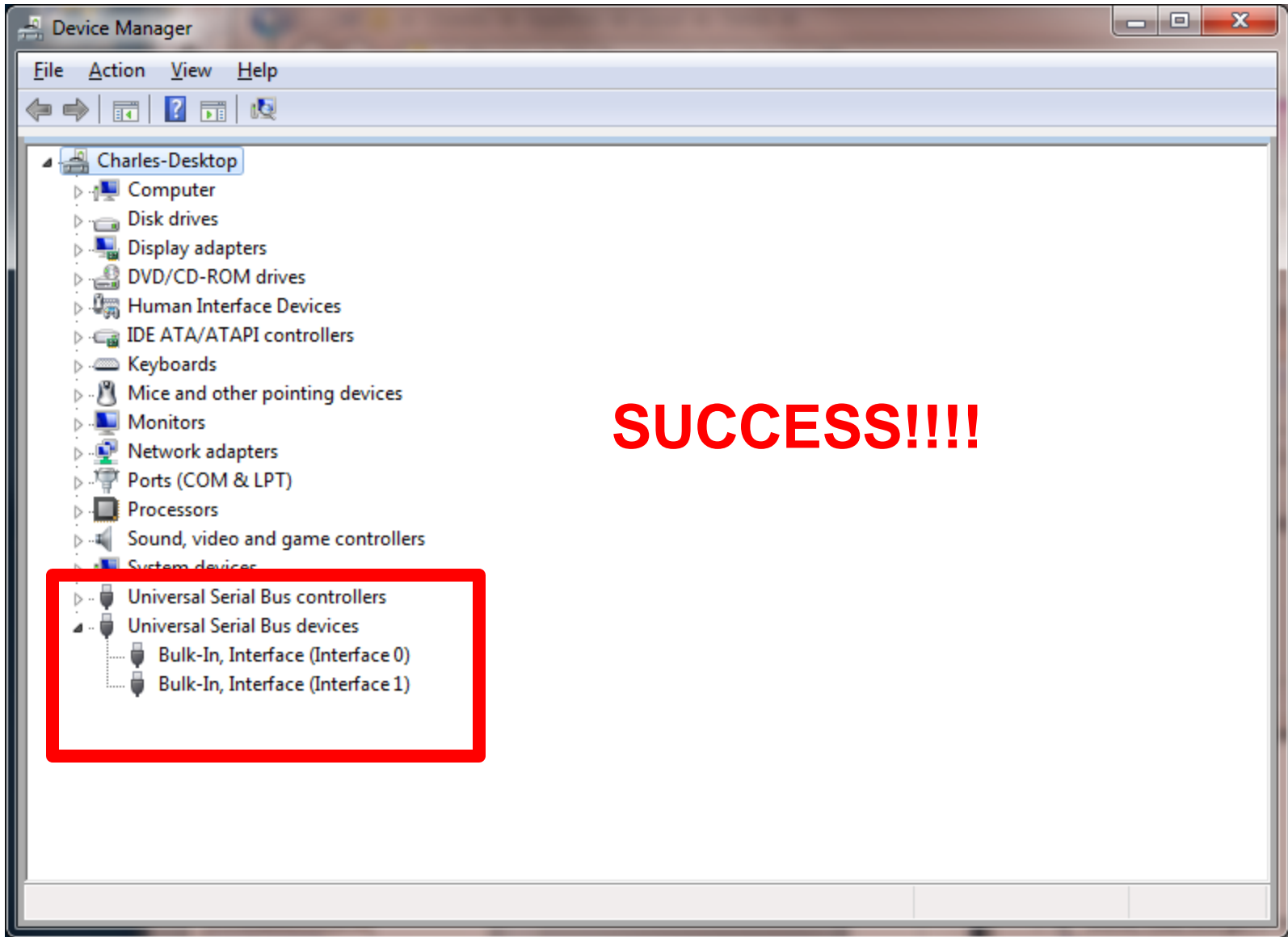
Run Zadig.exe as Administrator





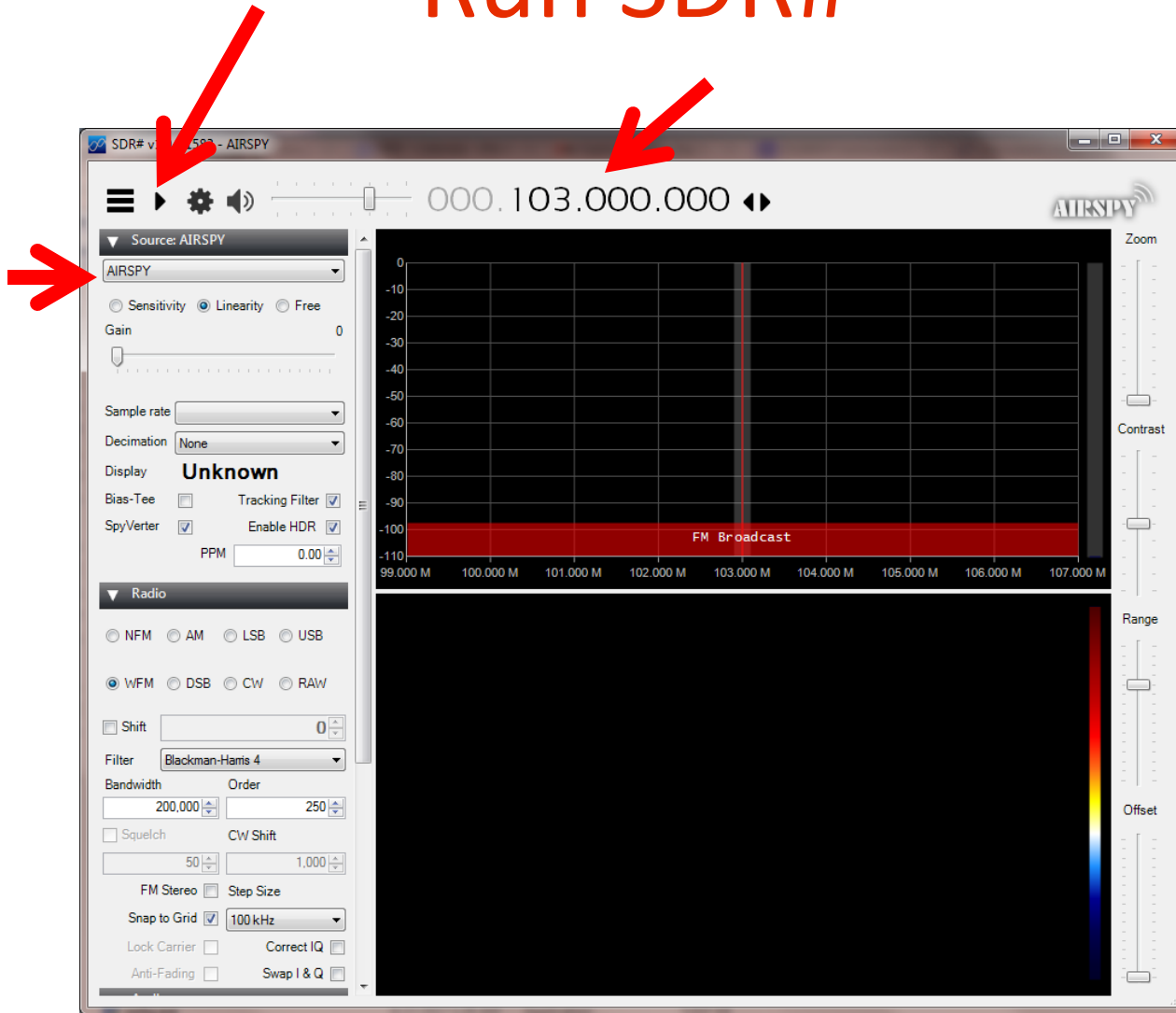
If you see this,
We need to run Zadig again

Made sure you
"Run as Administrator"

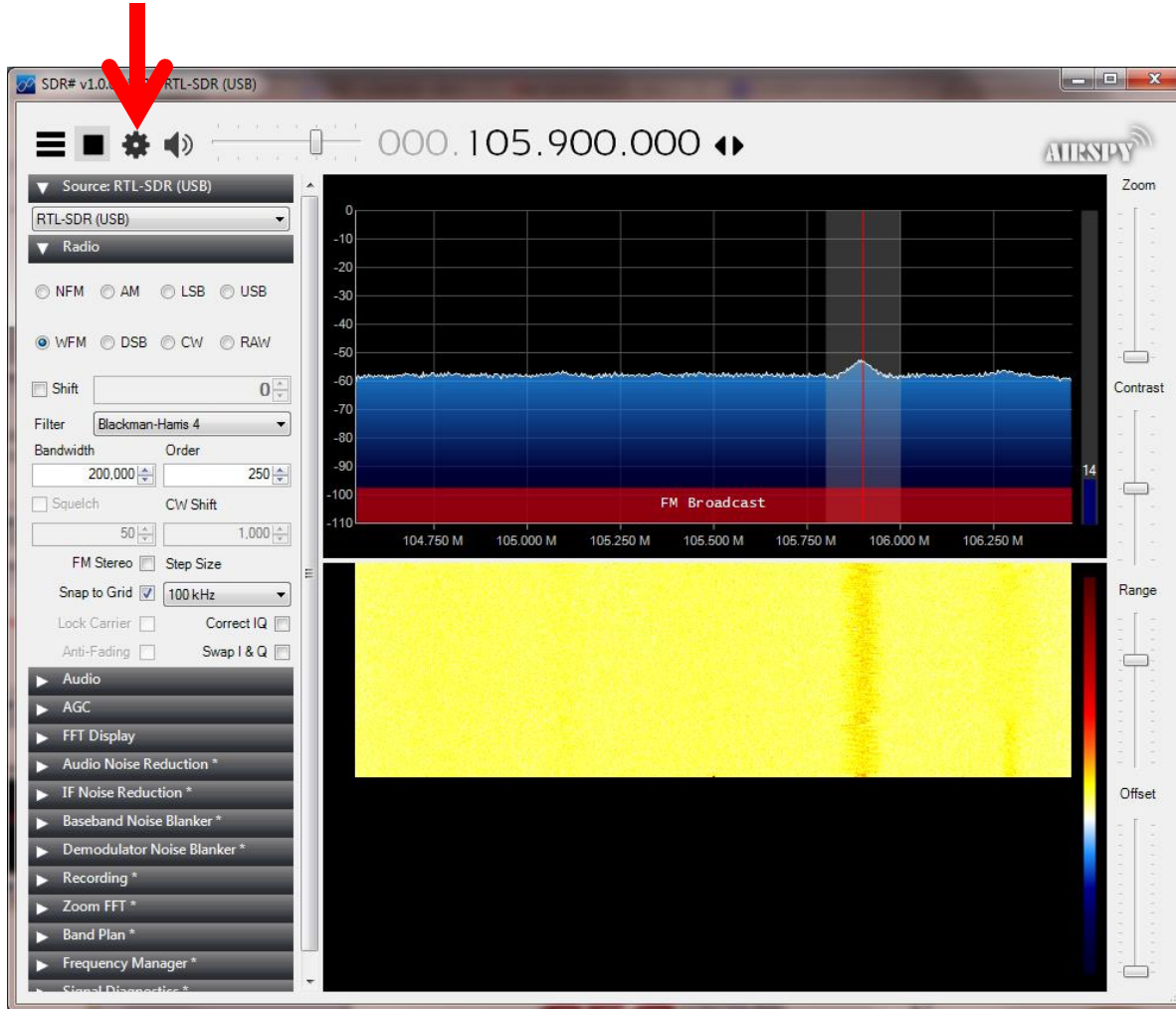


SUCCESS!!!!

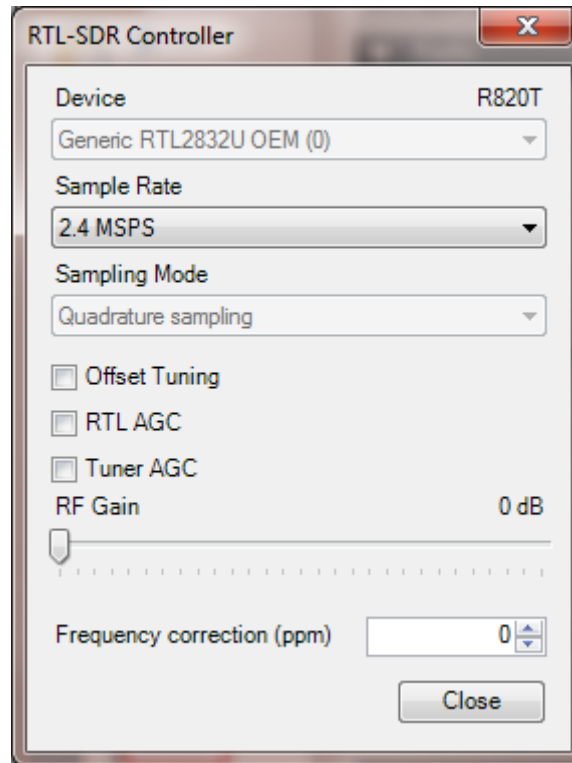
Run SDR#



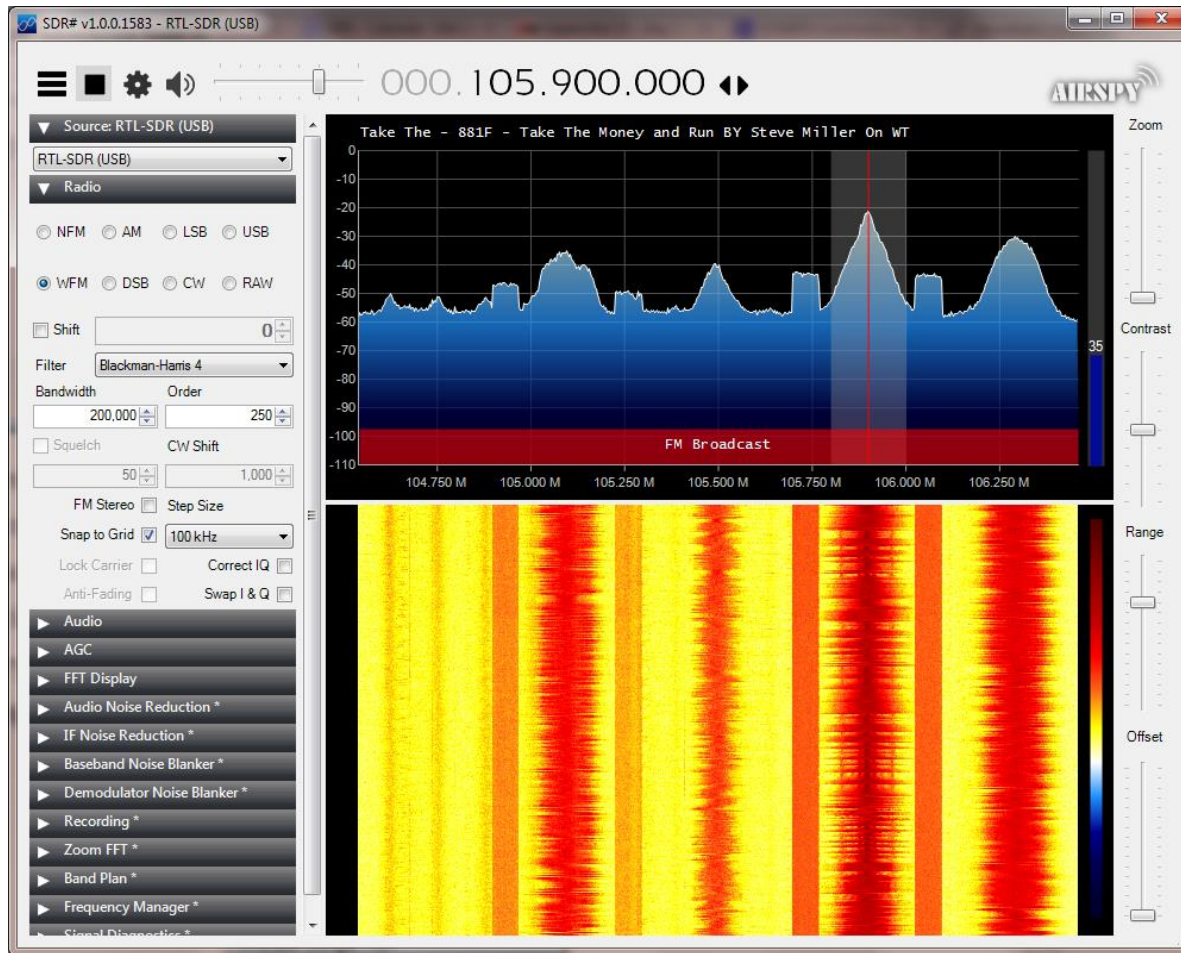
Noise!



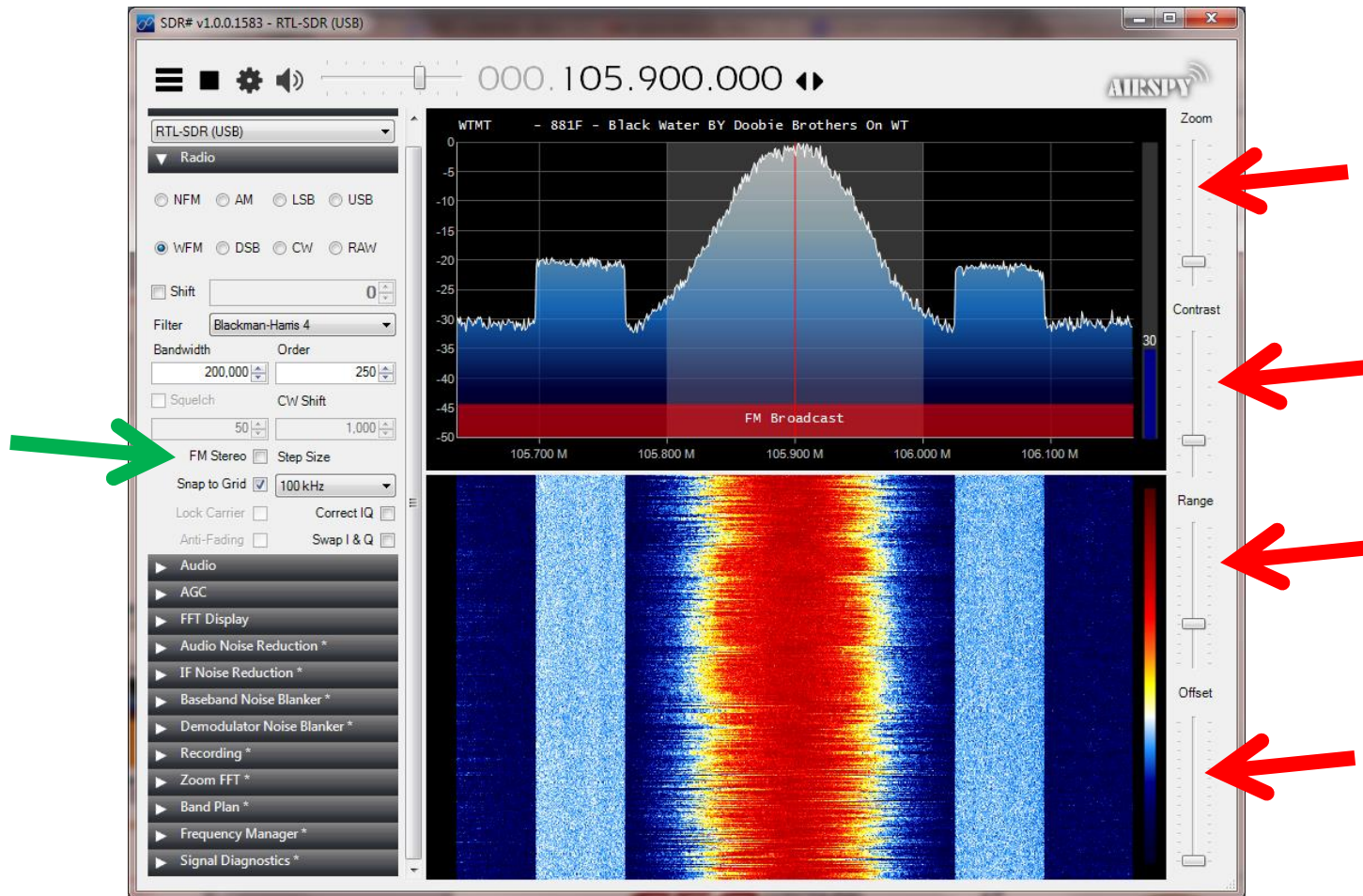
We need to either turn up RF or use AGC



Now We are Rocking

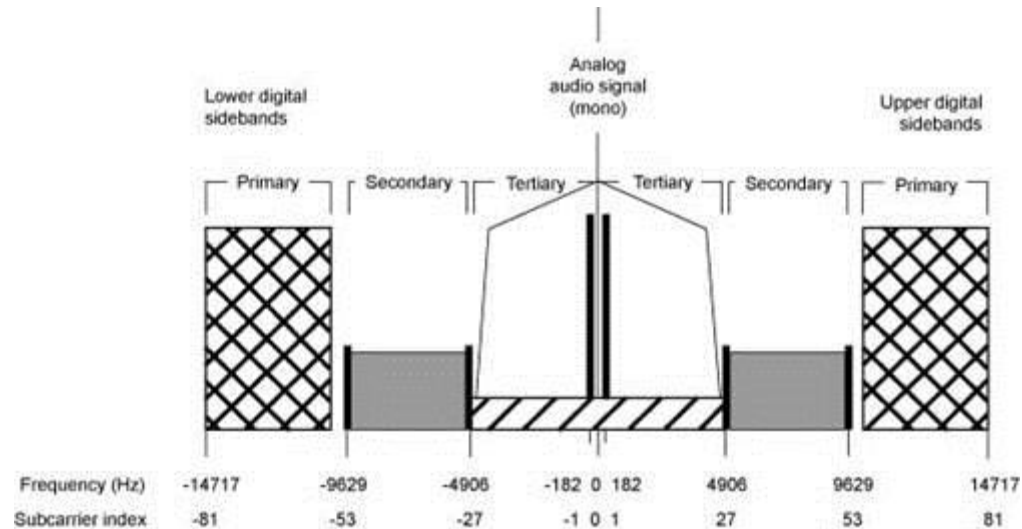


Play with these to get the signal centered and showing most info

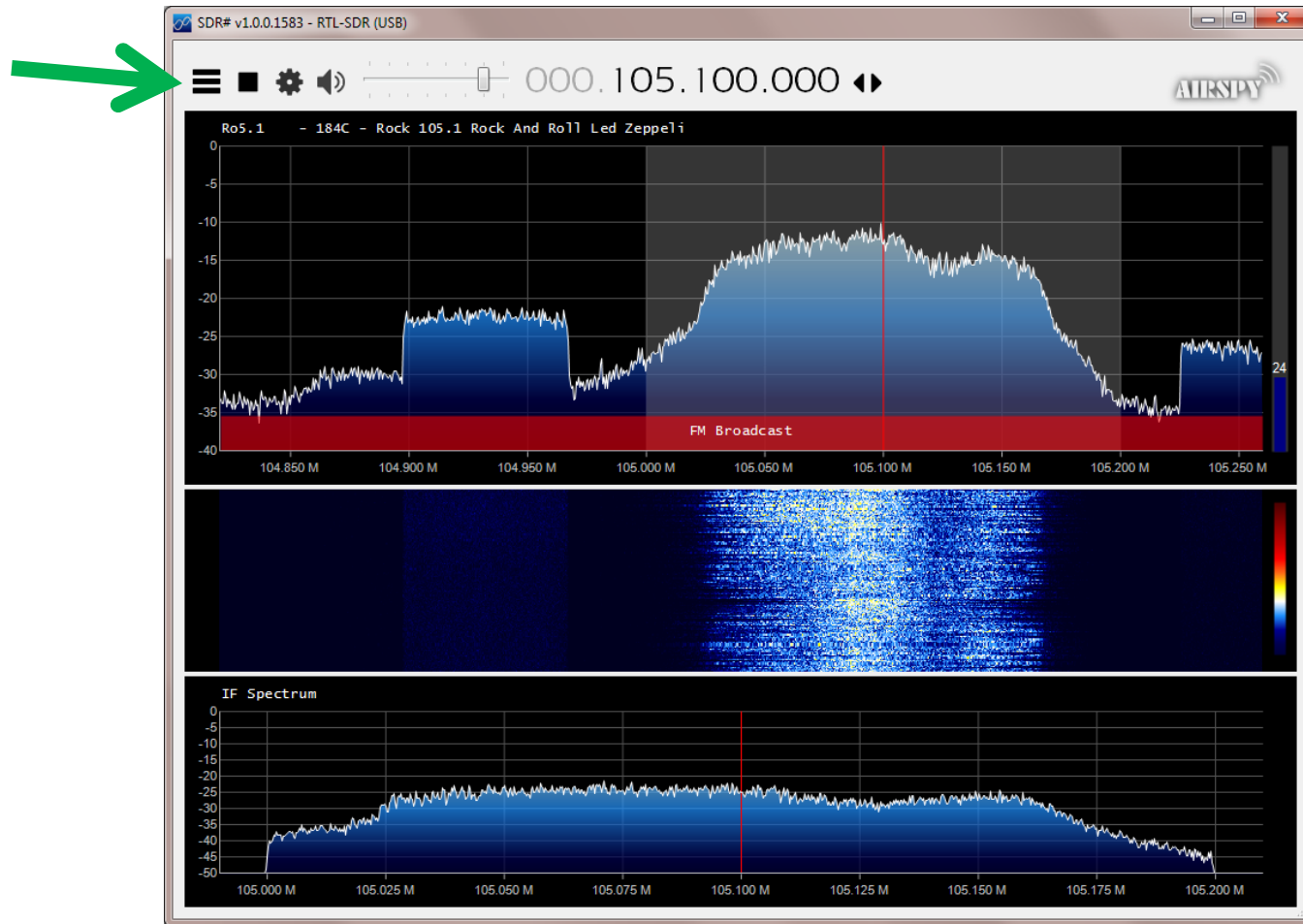


What are those huge sidebands?

FM HD or digital radio (Hybrid Analog / Digital)



Click on Menu to get full window



Fine Tuning SDR#

- Increase the FFT resolution to at least 16384 (ideally 32768 or higher if your computer is powerful enough) under the “FFT Display” heading on the left menu to give yourself a clearer higher resolution spectrum and waterfall image.
- Enable the “Correct IQ” setting to remove the center spike
- Turn off the “Snap to grid” setting

Challenges

- Look up the tower / approach / ATC frequencies for the local airport. Monitor (AM)
- Look for local amateur radio repeaters (NFM)
<http://www.artscipub.com/repeaters/>
 - Find the squelch function to quiet the audio when the repeater is not in use.
- Place antenna next to an embedded processor board – look for harmonics and noise

Other Dongles

- Once you have these drivers installed, most other RTL-SDR devices should work. Try any that you have
- Due to the peculiarities of Windows, you may have to run zadig.exe again if you move the dongle to a different USB port on the computer

For Tomorrow

- Sign up for the free 30-day trial of Matlab and Simulink at https://www.mathworks.com/programs/trials/trial_request.html
- *Get the RTL-SDR support package from <https://www.mathworks.com/hardware-support/rtl-sdr.html>*
- *Under “Supported Hardware” download the free book and files*

Note

- If you will be using Matlab and have not installed it yet, you need to do so before tomorrow – it takes a long while!

Question 3 – Will you be doing the Matlab exercises?

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Please stick around as I answer your questions!

- Please give me a moment to scroll back through the chat window to find your questions
- I will stay on chat as long as it takes to answer!
- I am available to answer simple questions or to consult (or offer in-house training for your company)

c.j.lord@ieee.org

<http://www.blueridgetechnc.com>

<http://www.linkedin.com/in/charleslord>

Twitter: @charleslord

<https://www.github.com/bradatrainng>