

# RTLSDR Scanner

Wideband RF Spectrum Scanning

<http://eartoearoak.com/software/rtlsdr-scanner>

# Contents

---

Copyright	4
License	4
Contributors	4
Further Information	4
<b>Introduction</b>	<b>5</b>
What is RTLSDR Scanner?	5
Required Hardware	5
Installation	5
Common Terms	5
Band Offset	5
Calibration	5
Dongle	5
Dwell	5
FFT Size	6
Gain	6
Local Oscillator (LO)	6
Scan	6
Server	6
Sweep	6
Power Spectral Density	6
Window Function	6
<b>Graphical User Interface</b>	<b>7</b>
Main Window	7
Menu Bar	7
File	7
Edit	8
Scan	8
Tools	8
Help	8
Graph	8
Standard Controls	8
Plot	9
Additional Controls	9
Spectrogram	9
Additional Controls	9
3D Spectrogram	9
Additional Controls	9
Tool Bar	9
Properties Window	11
Preferences Window	12
General	12
Advanced	13
Continuous Scans	13
Plot View	13
Devices	13

## RTLSDR Scanner

Window Function Window	14
Compare Window	14
Auto Calibration Window	14
Advanced Device Settings Window	15
<b>Command Line Interface</b>	<b>16</b>
Format	16
Switches	16
File	16
Start	16
End	16
Gain	16
Dwell	16
FFT	16
LO	16
Index	17
Remote	17
Help	17
Examples	17
<b>Illustration Index</b>	<b>18</b>
<b>Alphabetical Index</b>	<b>19</b>

## Copyright

This document is Copyright © 2014 Al Brown

The RTLSDR Scanner software is Copyright © 2012 – 2014 Al Brown

## License

Both this document and the RTLSDR Scanner is licensed under the GNU General Public License version 3 (<http://www.gnu.org/licenses/gpl.html>).

## Contributors

Contributors to this document and the RTLSDR Scanner can be found at the GitHub page:  
<https://github.com/EarToEarOak/RTLSDR-Scanner/graphs/contributors>

## Further Information

General information: <http://eartoearoak.com/software/rtlsdr-scanner>

Installation instructions: <http://eartoearoak.com/software/rtlsdr-scanner/rtlsdr-scanner-installation>

Code repository: <https://github.com/EarToEarOak/RTLSDR-Scanner>

## Introduction

---

### What is RTLSDR Scanner?

RTLSDR Scanner is a wideband spectrum analyser for RTLSDR dongles which allows the visualisation of radio frequency signals.

The software is cross-platform and runs under Linux, Windows and OS X.

RTLSDR Scanner provides both GUI and command line interfaces.

### Required Hardware

- A PC, Mac or an embedded Linux platform such as the Raspberry Pi.
- A compatible RTLSDR dongle, see the OsmoSDR page for more details at <http://sdr.osmocom.org/trac/wiki/rtl-sdr>

### Installation

Installation of the RTLSDR driver and library dependencies are beyond the scope of this document, further details can be found at: <http://eartoearoak.com/software/rtlsdr-scanner/rtlsdr-scanner-installation>

### Common Terms

#### Band Offset

The frequency offset where data is taken from to give a smooth scan and overcome the non-linear frequency response of the dongle.

#### Calibration

The frequency compensation to apply to scanning to overcome errors in the dongle, specified in parts per million (ppm).

#### Dongle

The RTLSDR USB device to use to sample the radio data.

#### Dwell

The time spent sampling at each frequency step, longer dwell times will slow the scanning speed but potentially reduce noise. For short-lived signals a fast dwell time should be used otherwise it's

amplitude may be significantly reduced.

### **FFT Size**

The number of bins used for Fast Fourier Transform analysis, larger values give an increased frequency resolution but require more computational power and higher memory usage.

### **Gain**

The gain (amplification) specified in Decibels (dB) to set the dongle to during a scan.

### **Local Oscillator (LO)**

The frequency offset to apply to scans if an external frequency converter (mixer) is used. Up and down converters are used to extend the tuning range to the dongle. For up-converters the offset is positive and negative for down-converters.

### **Scan**

One or more sweeps of the frequency range.

### **Server**

A dongle connected to a network which provides data via the *rtl\_tcp* utility.

### **Sweep**

A single pass of the frequency range.

### **Power Spectral Density**

The method for converting the radio data into a frequency spectrum.

### **Window Function**

A mathematical function used to reduce the effects of spectral leakage and noise when analysing data. Most users will probably want to leave this at it's default (Hamming window).

## Graphical User Interface

### Main Window

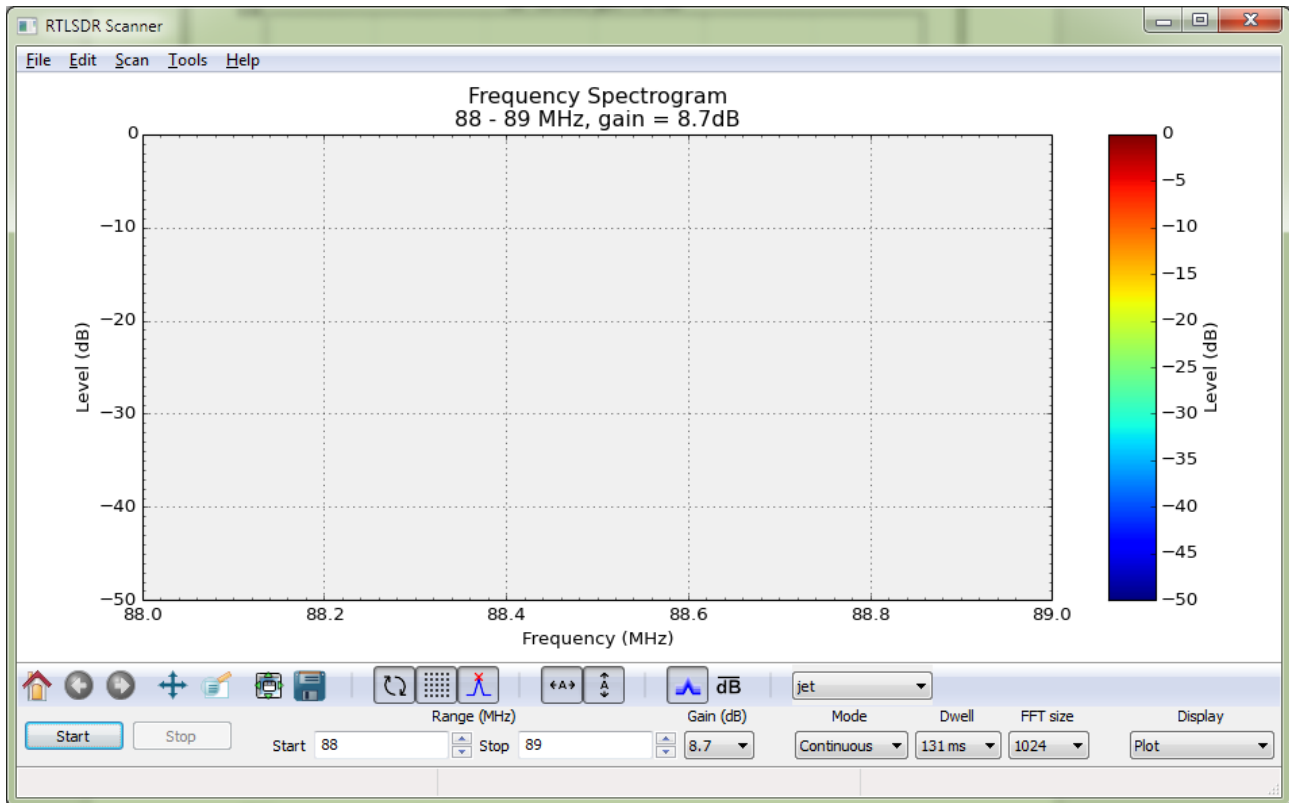


Image 1: Main Window

The main window is split into 3 main areas; the Menu Bar, the Graph and Tool Bar.

### Menu Bar

#### File

- Open... Open a scan.
- Recent Files... A list of recently used files.
- Save As... Save a scan.
- Export... Export a scan
- Properties... Properties of the current scan.
- Exit Exit the program.

## RTLSDR Scanner

### *Edit*

- Preferences... Show the preferences page.

### *Scan*

- Start Start a scan.
- Stop Immediately stop the scan.
- Stop at end Stop scanning at the end of the current sweep.

### *Tools*

- Compare... Compare two scans.
- Auto Calibration... Attempt to calibrate the dongle with a known frequency.

### *Help*

- Help... Open up further information from the RTLSDR Scanner page.
- About... Basic information about the program









## Graph

A plot of the scanned spectrum, three modes are currently available; Plot, Spectrogram and 3D Spectrogram.

A toolbar is available under the graph which allows panning and zooming in addition to plot specific commands.





The mouse wheel can be used to zoom 2 dimensional plots by first clicking the graph.

### *Standard Controls*

-  Home Zoom to the default limits of the plot.
-  Back Zoom to the previous view of the plot.
-  Forward Zoom to the next plot view.
-  Pan Pan the plot.
-  Zoom Zoom to an area of the plot.
-  Subplots Change the margins of the plot.
-  Save Save the current plot as an image.
-  Live update Update the plot as new data is processed (can be slow).





## RTLSDR Scanner

-  Grid Display a grid on the plot.
-  Label peak Display a marker and label at the peak of the last sweep.
-  Auto frequency Auto range the frequency axis to display all data.
-  Auto level Auto range the level axis to display all data.
- Colour map The mapping of levels to colour.

### Plot

A plot of the level versus frequency.

#### Additional Controls

-  Fade plots Fade previous sweeps
-  Average plots Average all the sweeps.

### Spectrogram

A plot of time versus frequency, level is displayed as colour. Often called a waterfall plot.



#### Additional Controls

-  Auto time Auto range the time axis to display all data.

### 3D Spectrogram

A three dimensional plot of frequency versus time versus level.

#### Additional Controls

-  Auto time Auto range the time axis to display all data.
-  Wireframe Plot the spectrum as a wireframe instead of colouring the faces.

### Tool Bar

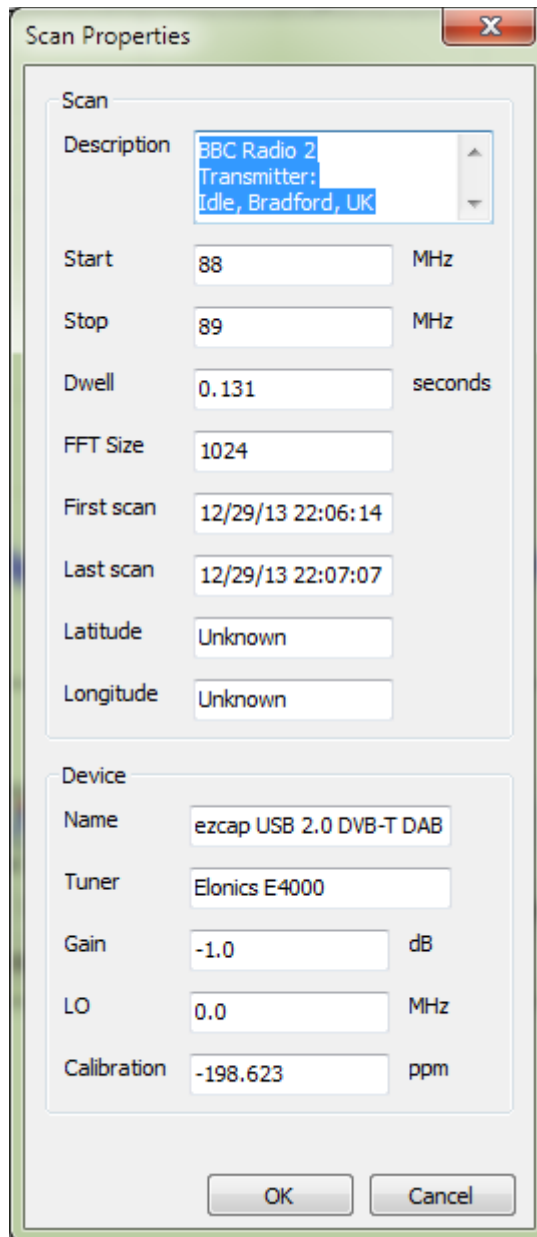
The tool bar is used to control the main functions of the scanner.

- Start Start a scan.
- Stop Immediately stop the scan.
- Range The frequency range.
  - Start The start frequency in megahertz.
  - Stop The end frequency in megahertz.
- Gain The dongle gain in Decibels.

## RTLSDR Scanner

- Mode                      Perform a single or multiple sweeps.
  - Single                      Only run a single sweep
  - Continuous                Run multiple sweeps until the scan is stopped,
- Dwell                      The dwell time for each scanning step.
- FFT Size                   The number of FFT bins to calculate.
- Display                    The type of plot to display.

## Properties Window



The image shows a 'Scan Properties' dialog box with two main sections: 'Scan' and 'Device'. The 'Scan' section contains fields for Description, Start, Stop, Dwell, FFT Size, First scan, Last scan, Latitude, and Longitude. The 'Device' section contains fields for Name, Tuner, Gain, LO, and Calibration. At the bottom are 'OK' and 'Cancel' buttons.

Scan	
Description	BBC Radio 2 Transmitter: Idle, Bradford, UK
Start	88 MHz
Stop	89 MHz
Dwell	0.131 seconds
FFT Size	1024
First scan	12/29/13 22:06:14
Last scan	12/29/13 22:07:07
Latitude	Unknown
Longitude	Unknown

Device	
Name	ezcap USB 2.0 DVB-T DAB
Tuner	Elonics E4000
Gain	-1.0 dB
LO	0.0 MHz
Calibration	-198.623 ppm

OK Cancel

Displays the known properties of the known scan, latitude and longitude information may be edited here.

## Preferences Window

**Preferences**

**General**

☒ Save warning

☐ Level alert (dB) -20

Background colour

Colour map: jet

**Advanced**

PSD Overlap (%) 0 0 75

Window: Hamming

**Continuous Scans**

☐ Average Scans

☒ Retain previous scans

Max scans: 20

**Plot View**

☒ Fade previous scans

Line width: 0.4

**Devices**

Select	Device	Tuner	Serial Number	Index	Gain (dB)	Calibration (ppm)	LO (MHz)	Band Offset (kHz)
<input checked="" type="checkbox"/>	Generic RTL2832U OEM	Rafael Micro R820T	00000013	0	8.7	0.000	0.000	250
<input type="checkbox"/>	192.168.0.97:1234	Rafael Micro R820T			8.7	0.000	0.000	250

Add Delete

OK Cancel

Allows customisation of the software.

### General

- Save warning Warn if a scan has not been saved before overwriting or exiting.
- Level alert Beep if the scan level is equal or greater than this level.
- Background colour The background colour of graph planes.
- Colour map The mapping to convert a level to colour in the view.

## Advanced

- PSD overlap      Overlap percentage for power spectral density calculations.
- Window function      Change the window function used while scanning.

## Continuous Scans

Options pertaining to the continuous scan mode.

- Average scans      Average the current sweep with the previous one.
- Retain previous scans      Keep previous sweeps.
- Max scans      Maximum number of sweeps to keep

## Plot View

Settings related to the plot display

- Fade previous scans      Fade out older scans in the view.
- Line width      Line width to use when plotting

## Devices

A list of currently detected dongles and server settings.

- Select      Use this column to select a device to scan with.
- Device      Displays the name of the dongle or the host and port of a server.
- Tuner      The tuner type in the dongle.
- Serial Number      The serial number of the dongle (not supported for servers)
- Index      The USB index of the dongle.
- Gain      The gain to set the dongle to in Decibels.
- Calibration      The frequency calibration to apply to the dongle in parts per million.
- LO      Local oscillator offset – used with frequency converters.
- Advanced      Click to open the advanced device settings window.
- Add      Add a server
- Delete      Delete the currently select server

## Window Function Window

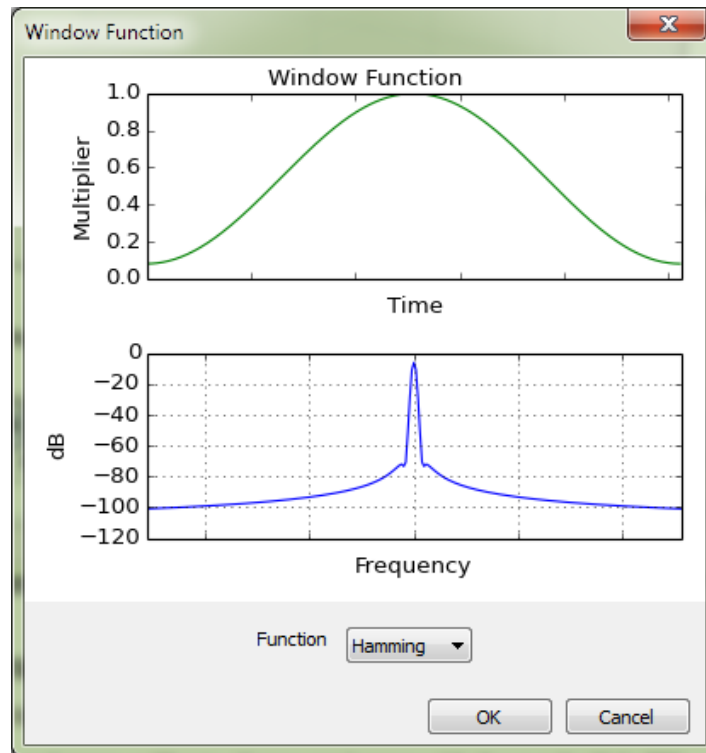


Image 2: Window Function

Allows the setting of the window function that the scanner applies to incoming samples. This window is meant primarily for educational purposes as the default Hamming window gives the best results.

The first graph (green) displays how the window function tapers off data at the beginning and end of the sample to reduce leakage and noise when the sample is converted into frequency data.

The bottom graph (blue) displays the frequency response of the window function. The software takes data from the flattest sections of the graph ignoring the large peak which corresponds to 0Hz.

## Compare Window

Allows you to load two different scans and display the difference between them if their frequency bins coincide.

The first plot is shown in blue, the second in green and the difference in red.

## Auto Calibration Window

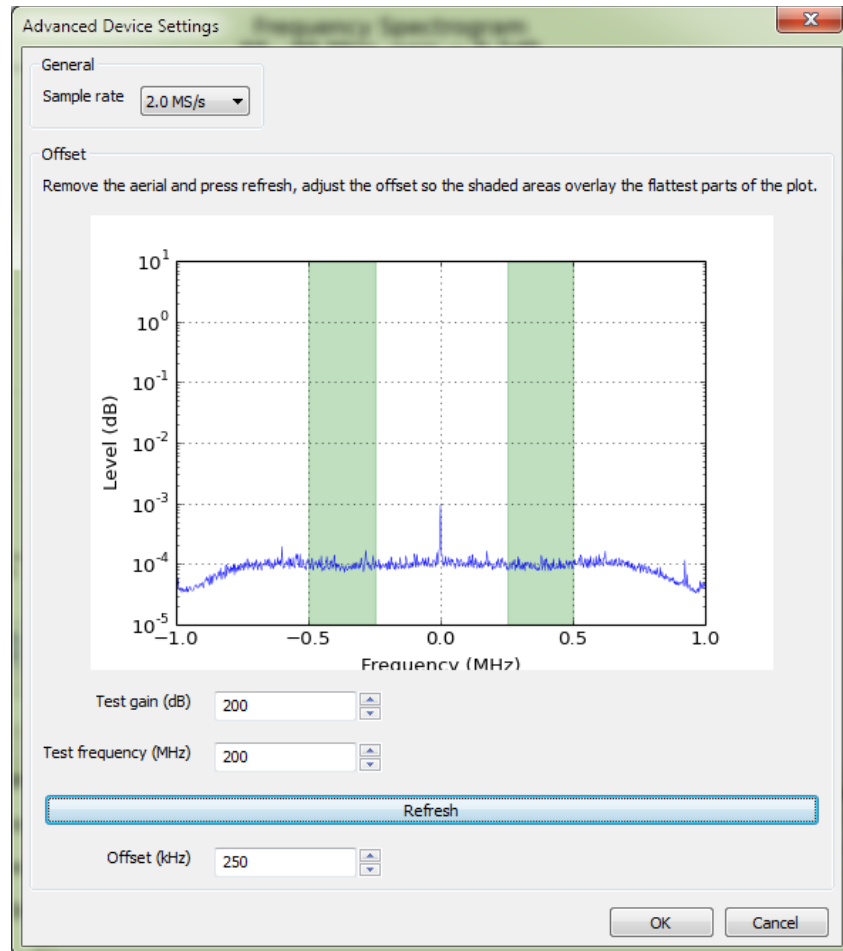
Basic calibration to a **known** signal.

Set the frequency and press calibrate, if you are happy with the result click OK.

Suitable signals are constant, unwavering signals such as that from a signal generator.

Real world sources such as FM radio transmissions can be used although the precision is reduced. In these cases it is recommended to set the dwell time to 1000ms to reduce errors.

### Advanced Device Settings Window



*Image 3: Advanced Device Settings*

This window allows you to select the sample rate and pick the flattest part of the spectrum returned by the dongle.

- Pick the desired sample rate.
- Disconnect the antenna from the dongle and ideally replace it with a 50 ohm load.
- Press refresh and wait for the spectrum to be displayed.
- Adjust the offset so the green bars cover the flattest section.

## Command Line Interface

---

Scanning can be initiated from the command line.

### Format

```
rtlsdr_scan.py    [-h]
                  [-s START] [-e END]
                  [-g GAIN] [-d DWELL] [-f FFT] [-l LO]
                  [-i INDEX | -r REMOTE]
                  [file]
```

### Switches

#### File

The file name to save the scan to, either ending in '.rfs' for native file or '.csv' to export to a comma separated values file.

#### Start

-s, --start                      Start of the frequency range in megahertz.

#### End

-e, --end                        End of the frequency range in megahertz.

#### Gain

-g, --gain                       Scan gain in Decibels (optional, default – 0dB).

#### Dwell

-d, --dwell                      Dwell time in seconds (optional, default – 131ms).

#### FFT

-f, --fft                        The number of FFT bins (optional, default – 1024).

#### LO

-l, --lo                         The local oscillator offset in megahertz (optional, default – 0MHz).



## RTLSDR Scanner

### Index

`-i, --index` The zero-based index of the dongle (optional, cannot be used with `-r`).

### Remote

`-r, --remote` The server host and port (optional, cannot be used with `-i`).

### Help

`-h, --help` Display help information (optional).

### Examples

Scan from 88 to 108 MHz, saving to 'scan.rfs'

```
rtlsdr_scan.py -s 88 -e 108 scan.rfs
```

Scan from 430 to 436MHz, with a gain of 8.7dB and a dwell of 16ms, saving to 'test.rfs':

```
rtlsdr_scan.py -s 430 -e 436 -g 8.7 -d 16 test.rfs
```

Scanning using a second dongle:

```
rtlsdr_scan.py -s 88 -e 108 -d 1 scan.rfs
```

Scan using a server by name:

```
rtlsdr_scan.py -s 88 -e 108 -r rtlserver:1234 scan.rfs
```

Scan using a server by address:

```
rtlsdr_scan.py -s 88 -e 108 -r 192.168.0.22:1234 scan.rfs
```

## Illustration Index

---

Image 1: Main Window.....	7
Image 2: Window Function.....	14
Image 3: Advanced Device Settings.....	15

## Alphabetical Index

---

About	8
Add	13
Advanced	13
Advanced Device Settings	15
Auto Calibration	8, 14
Auto range frequency	9
Auto range level	9
Auto range time	9
Average	9, 13
Back	8
Band Offset	5
Calibration	5, 13
Colour map	9, 12
Compare	8, 14
Continuous	10, 13
Delete	13
Device	13
Devices	13
Display	10
Dongle	5
Dwell	5, 10, 16
End	16
Exit	7
Export	7
Fade plots	9
Fade previous scans	13
FFT	16
FFT Size	6, 10
File	16
Forward	8
Gain	6, 9, 13, 16
General	12
Grid	9
Help	8, 17
Home	8
Index	13, 17
Label peak	9
Level alert	12
Live update	8
Local Oscillator	6, 13, 16
Main Window	7
Max scans	13
Menu Bar	7
Mode	10
Mouse wheel	8

## RTLSDR Scanner

Open	7
Pan	8
Plot	9
Plot View	13
Power Spectral Density	6
Preferences	8, 12
Properties	7, 11
PSD overlap	13
Range	9
Recent Files	7
Remote	17
Retain previous scans	13
Sample rate	15
Save	8
Save As	7
Save warning	12
Scan	6
Serial Number	13
Server	6
Single	<b>10</b>
Start	8p., 16
Stop	8p.
Stop at end	8
Subplots	8
Sweep	6
Tuner	13
Waterfall	9
Window Function	6, 13p.
Wireframe	9
Zoom	8