

A USER'S GUIDE TO SDR# (SDRSHARP)

SDR# (aka “SDRSharp”) is an easy-to-use yet small and fast Software Defined Radio application for Windows created by Youssef Touil with collaborative assistance from other talented software engineers. SDR# is written in C#, a modern, general-purpose, object-oriented programming language developed by Microsoft.

SDR# is intended as a Digital Signal Processing application for use with a wide range of RF hardware, including:

- SoftRock
- FiFiSDR
- FUNcube Dongle
- SDR-4
- LazyDog's LD-1
- SDR-IQ
- SDR-14
- RTL2832U / RTLSDR
- Any sound card based SDR front end
- Any ExtIO based SDR front end

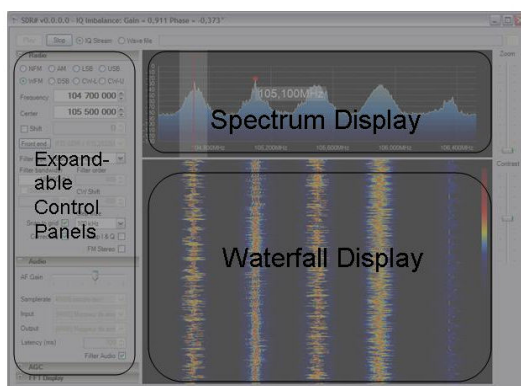
More radios will be supported as interest demands. Latest information can always be found at the SDR# website: <http://sdrsharp.com/> and on the #SDR channel on IRC, or via the mail reflector: <http://uk.groups.yahoo.com/group/SDRSharp/>

The SDR# human interface is intuitive and flexible to use. “Run” and “Stop” buttons are found the very top of the screen, along with the ability to select live data from a connected IQ stream or playback of stored files.

The balance of the SDR# screen consists of three functional areas:

- Expandable control panels along the left-hand side
- Tuning controls and spectrum display at the top-right
- Waterfall display at bottom-right
- Controls for spectrum Zoom and waterfall Contrast along the rightmost edge

SDR# Screen Layout



EXPANDABLE CONTROL PANELS

SDR# comes with four standard control panels:

- Radio
- Audio
- AGC
- FFT Display

Each panel can be minimized by clicking on the “-“ sign, or expanded by clicking on the “+” sign.

RADIO:

The Radio panel includes information needed to configure, control, and tune the Software Defined Radio. Here is a brief description of functions that are available:

1. MODE Selections include Narrow FM (NFM), AM, Lower Sideband (LSB), Upper Sideband (USB), Wide FM (WFM), Double Sideband (DSB), and CW with lower or upper-side offset (CW-L and CW-U)

NFM is used for all FM modes except FM broadcast, which is WFM.

2. FREQUENCY

This box shows the frequency that is actually being received. Direct entry is possible, but must be within range of the center frequency that is presently set. Click the mouse anywhere in the spectrum display to tune to that frequency.

3. CENTER

This box shows the center frequency that the RF front-end is tuned to. The combination of FREQUENCY and CENTER displays can be used to tune SDR#. Once the CENTER frequency is set, any signal within the spectrum display can be tuned, based on the sample rate of the RF front end. See “Spectrum Display” for information on tuning using the mouse, otherwise center frequency (in Hz) can be entered directly.

4. FRONT END

Various RF hardware options can be selected by clicking the down-arrow just to the right of the FRONT END button. Available devices can be selected via the pull-down menu, and applicable defaults will be displayed.

The FRONT END button brings up a menu containing any configuration options that are available for the selected device.

5. FILTER TYPE, FILTER BANDWIDTH, FILTER ORDER

These three options allow customization of the window function, bandwidth, and order of the DSP filter used by SDR#. Default options are chosen for nominal operation in each model, but can be changed as desired, and the specified bandwidth will be shown as a highlighted area on the spectrum display. Filter settings will return to the default values when SDR# is restarted.

6. SQUELCH

Clicking the box enables the Squelch function, which mutes the audio output until the received signal exceeds the threshold value that is determined by the value in the box below. Lower values “loosen” the squelch or decrease the signal level needed for audio to be heard. Higher values require stronger signals before audio is heard. Squelch is available in AM and NFM modes only.

7. CW SHIFT

This value determines the offset between transmit and receive frequencies in the CW modes for devices having transmit capability.

8. SNAP TO GRID, STEP SIZE

These functions help to simplify tuning for channelized operation, and to customize the tuning response of SDR# for all modes. A wide range of step size options can be selected from the pull-down menu to accommodate various needs. For example, 12.5 kHz steps are used in aircraft communications, whereas single sideband requires tuning in increments of 100 Hz or less. The Snap-to-Grid option forces the tuned frequency to the nearest step size increment.

9. CORRECT IQ

SDR# has an original algorithm that compensates gain and phase imbalances between the IQ channels. Without this compensation strong signals are mirrored with respect to the center of the spectrum, as can be seen in the spectrum display of other SDR programs. This unique feature of SDR# should be left on unless there is a reason to disable it.

10. Swap I and Q

Most RF front ends will present I and Q signals in the proper way, but if not, click this box to swap them without changing hardware connections.

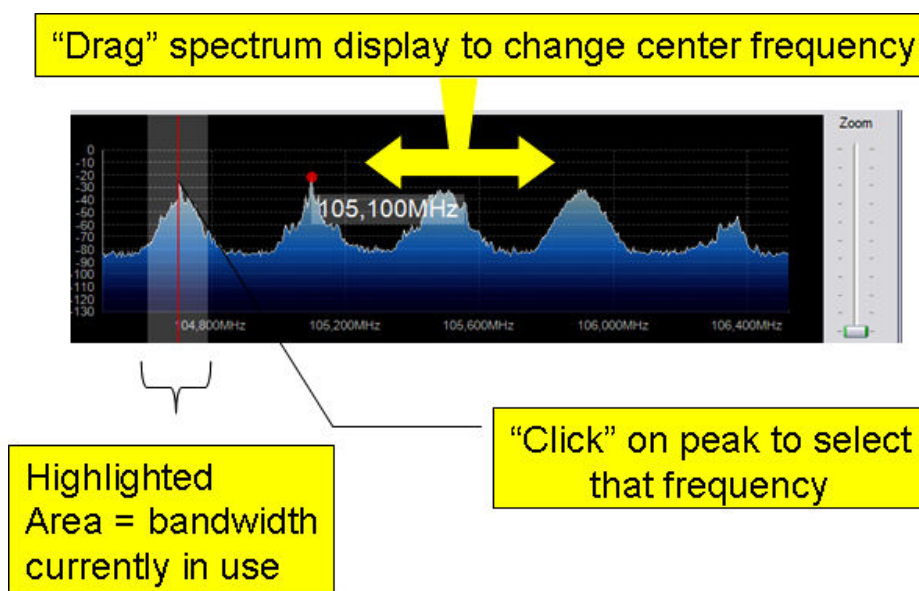
11. FM Stereo

When selected, stereo output is available in WFM mode (for broadcast FM listening)

12. Mark Peaks

Clicking this box toggles a visual indicator of peaks in the spectrum display as an aid for tuning.

USING THE SPECTRUM DISPLAY



Basic Radio Operation

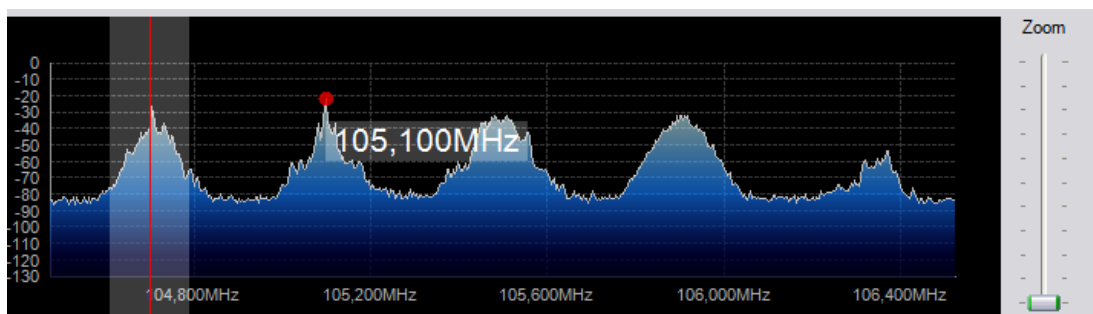
The screenshot shows the SDR# Radio settings window. On the left, three callout boxes point to specific settings: 'RF Front-End select' points to the 'Front end' dropdown menu; 'Custom settings (depends on front-end)' points to the 'Filter type' dropdown menu; and 'Tuning Step size' points to the 'Step size' dropdown menu. On the right, four brackets group the settings into categories: 'Mode Select' (radio mode buttons), 'Tuning' (frequency and center frequency fields), 'Filter' (filter type, bandwidth, and order), and 'Volume' (AF Gain slider). The 'Radio' section includes radio mode buttons (NFM, AM, LSB, USB, WFM, DSB, CW-L, CW-U), frequency and center frequency fields, a 'Shift' checkbox, a 'Front end' dropdown, a 'Filter type' dropdown, 'Filter bandwidth' and 'Filter order' fields, a 'Squelch' checkbox, 'CW Shift' and 'Step size' fields, 'Snap to grid' and 'Correct IQ' checkboxes, and 'Swap I & Q' and 'FM Stereo' checkboxes. The 'Audio' section includes an 'AF Gain' slider, 'Samplerate', 'Input', 'Output', and 'Latency (ms)' fields, and a 'Filter Audio' checkbox. The bottom section has checkboxes for 'AGC' and 'FFT Display'.

The above settings should enable basic SDR# Radio operation using RTL-SDR / RTL2832 USB DVB-T dongle. Default frequency and mode settings are for FM broadcast where signals are strong and something should be heard even with a limited antenna.

QUICK START: Select the Front End, Enter a Center Frequency and Mode, then click “Start”. Default settings should be sufficient for normal listening.

ANTENNA: The short antenna supplied with DVB-T dongles provides poor reception and should be replaced with a good VHF-UHF antenna mounted outdoors if possible. Low-loss RG-6/U coax is readily available at reasonable price. Adapters can be purchased to adapt the “F” connector used on RG-6/U to the PAL connector used on the dongle. Alternatively the supplied cable can be cut near the end and used to make an adapter patch cable. Details for making inexpensive wideband VHF/UHF antennas such as the discone can be found online. Old TV or scanner antennas, “rabbit ears”, etc can also be used.

SPECTRUM DISPLAY



The spectrum display shows a continuous display of the RF spectrum. The amount of spectrum displayed is a function of three factors:

1. The Sample Rate of the RF Front end. This determines the amount of RF spectrum that is digitized and sent to SDR# for digital processing.
2. The setting chosen in the “FFT Display” control panel.
3. The setting of the “Zoom” slider to the right of the display area. Fully down, the amount of spectrum displayed is the full amount that is provided by the RF Front End. As the slider is moved up, the display zooms-in on the frequency presently tuned, showing more detail of the signal being received, but less of the overall spectrum.

The relative amplitude of each signal can be estimated by comparing the height of each peak. With practice one can quickly identify the different modulation types, based on their appearance in the spectrum display.

Ability to easily tailor the spectrum display adds a great deal of capability to SDR#.

The FFT setting determines the base resolution of the spectrum display. A fairly low FFT setting (such as 4096) provides adequate resolution for many purposes yet places a minimal burden on the CPU. Increasing the FFT provides much greater resolution, but at the cost of increasing the load on the PC CPU, with the highest settings requiring so much computational time that audio becomes choppy. The general rule of thumb is to use as high a setting as needed for your purposes, but no more.

The zoom feature makes it easy to temporarily see more details without changing the base resolution. It is analogous to an old-time newspaper photo, where a magnifying glass enables you to see the dots that are always present in the image. Zooming-in on a signal makes it easier to tune to the exact center, and to view a limited chunk of spectrum in more detail.

The mouse can be used to change the center frequency by clicking and dragging the background of the spectrum display to the right or left. Clicking on any part of the display area will tune SDR# to that frequency.

OTHER EXPANDABLE CONTROL PANELS

AUDIO:

The Audio control panel allows control of the volume and selection of the audio source and destination. For most users the default choices will be OK. Those who need a source of unfiltered audio should unclick the “Filter Audio” box. For users who feed the output of SDR# to a digital decoding program of some sort, the Audio Output should be changed to Virtual Audio Cable or whatever alternative is used for this purpose.

AGC:

This panel provides control over the Automatic Gain Control feature of SDR#. Default settings should be OK for most users.

FFT Display:

Other than changing the resolution of the FFT as explained above, default settings should be OK for most users.

CUSTOM:

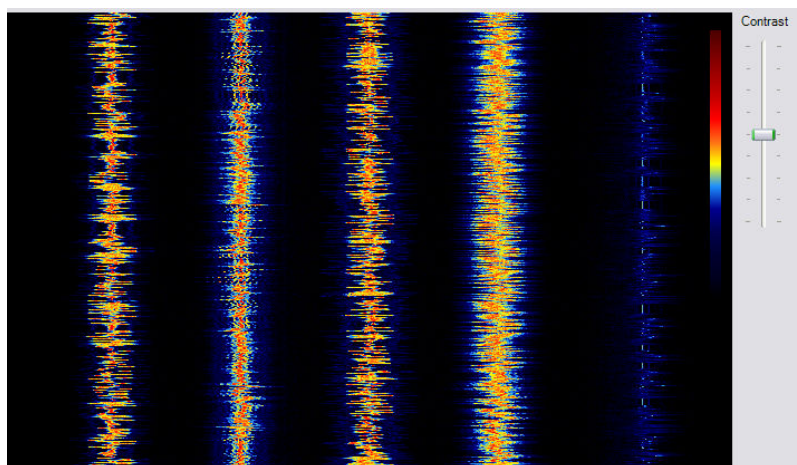
Developers are working on new features that add new functionality to SDR#, resulting in the addition of new expandable control panels for these features. If you have a version of SDR# that includes custom control panels, you will need to look to the SDR# website and discussion groups for further information. Some examples include:

AUTO TUNER – automatically tunes to peak signals much like a scanner, including logging frequencies and other enhancements.

TRUNKING – extracting control channel information from a 2nd dongle using Unitrunker to automatically follow trunked radio system

This ability to enhance SDR# will continue to evolve as the potential of software defined radio is explored and new applications created.

WATERFALL DISPLAY



The waterfall display is a time-varying spectral display, and brings an exciting new dimension to radio listening. Previously used in applications such as sonar, speech processing, and seismology, the waterfall (also known as “spectrogram”) display gives us a brief look back in time as signals appear at the top, and then scroll down and off the bottom of the display. The frequency of each signal is the same as in the spectrum display above, so the waterfall will show “wiggles” as we click and drag the spectrum display to change frequency. Since the waterfall is a 2 dimensional view (frequency vs. time), amplitude information is displayed through the horizontal width and color of the line in the waterfall rather than through the peaks.

A slider control allows customization of the display “Contrast”, but the default setting should be OK for most users. Black indicates no signal, and shades of blue, yellow and red correspond to increasingly higher received signal levels. A very strong signal will be almost solid red, while a weak signal will consist of mostly yellow and blue. Modulation type can be determined from the waterfall display as well, in fact the “dits and dahs” of a CW (Morse) signal can usually be read vertically as the display scrolls. Since the display color contrast is relative, the user can vary it to suit specific needs.

The Zoom control affects the waterfall display in the same way as the spectrum display.

FOR MORE INFORMATION:

1. the official SDR# website: <http://sdrsharp.com/>
2. shortcut to official download page: <http://sdrsharp.com/index.php/downloads>
Note: “Continuous Integration” or “nightly” versions contain latest enhancements and features
3. RTL2832 DVB-T dongle installation information: <http://rtl-sdr.org/softwarewindows>
NOTE: THE ABOVE PROCEDURE MUST BE FOLLOWED BEFORE RTL DEVICES CAN BE USED WITH SDR#!
4. Bob Rich’s standing download site for the latest version of his experimental code (Auto Tuner, Trunking, etc):
<https://public-xrp.s3.amazonaws.com/Release-latest.zip>
5. #rtl-sdr and #sdrsharp on Freenode IRC
6. Yahoo group: <http://uk.groups.yahoo.com/group/SDRSharp/>

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