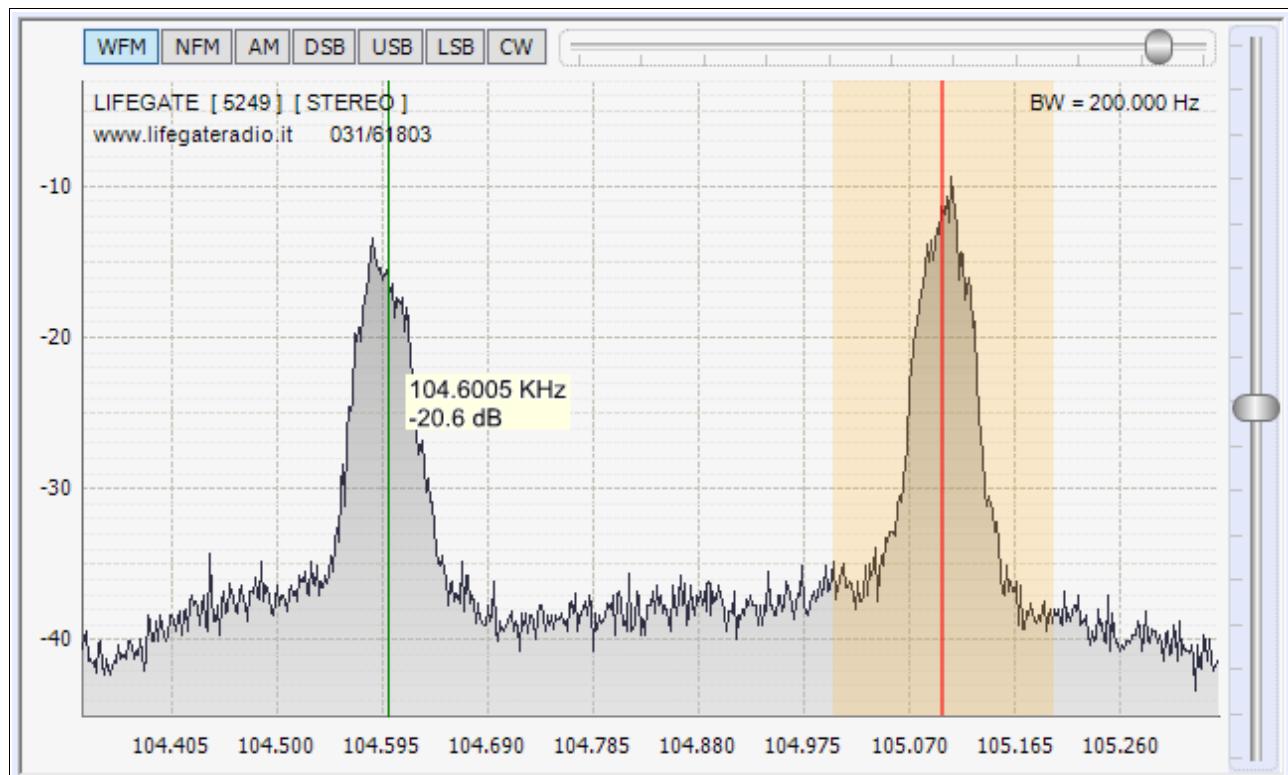
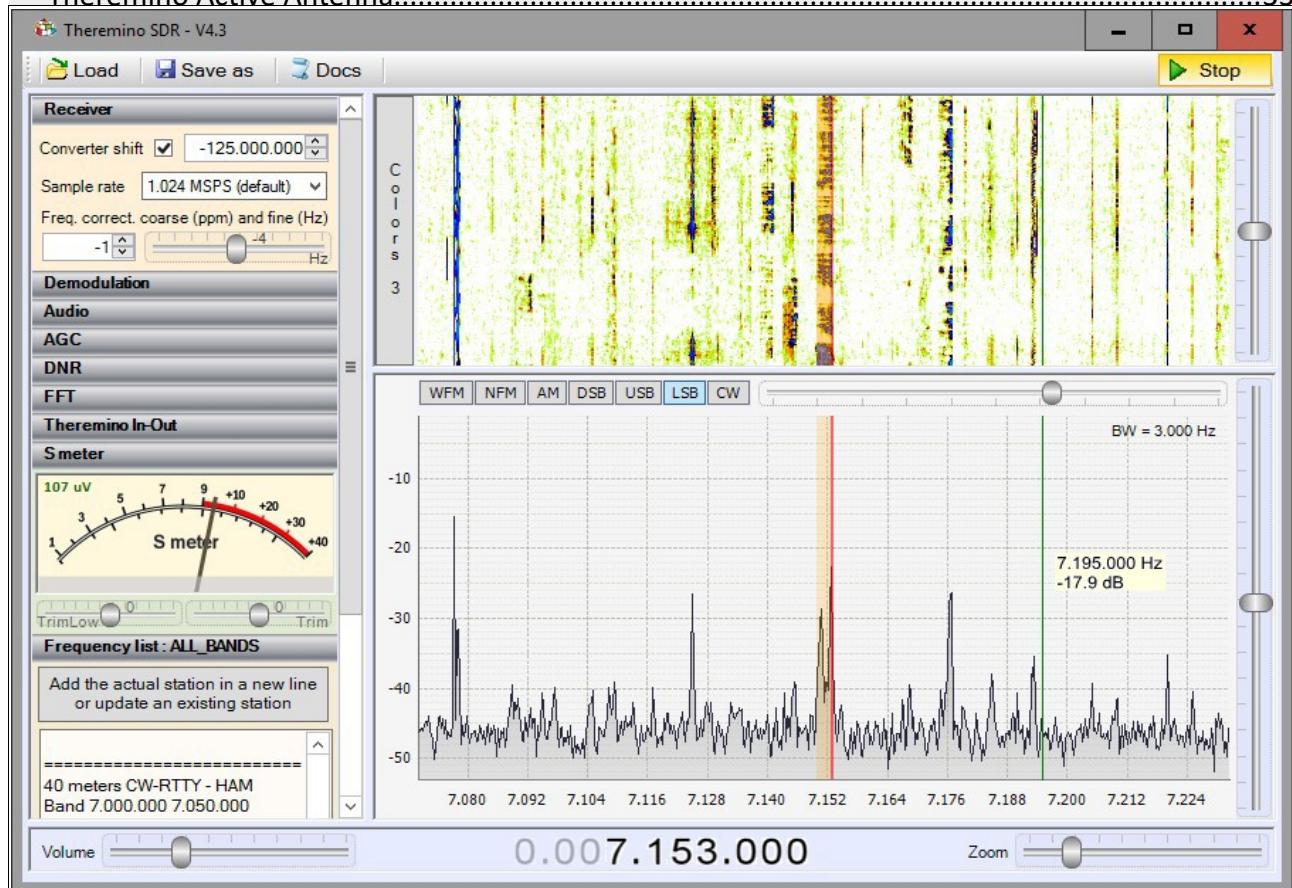


## Theremino System



# Theremino SDR instructions

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## What is Theremino SDR

Theremino SDR is a digital receiver, usable also as a spectrum analyzer. SDR stands for "Software Defined Radio" and this means that much of the work is done in software, both to reduce costs and to increase performance.



What remains, it is a minimum hardware equipment, which can be purchased for around eight euros (shipping included).

This model receives from short-wave (24 MHz), up to microwave (1.76 GHz).

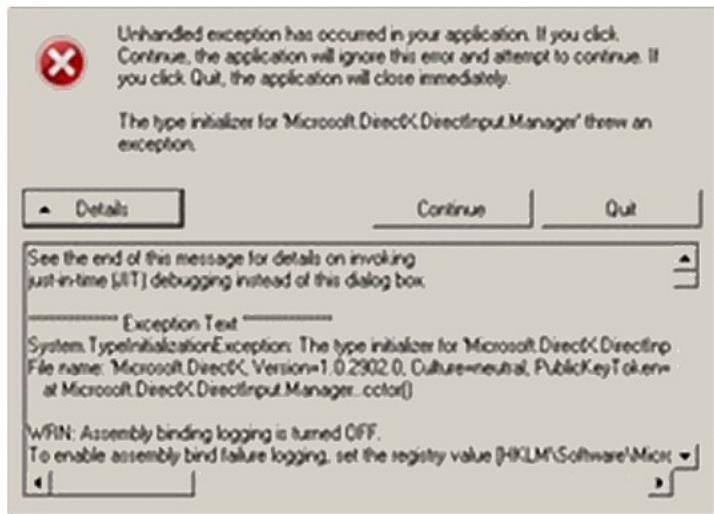
To receive long-wave, medium and short (from 10 kHz to 50 MHz), you have to add the Theremino upconverter, which can be built "Do It Yourself", with only some components, as explained in this page:

<http://www.theremino.com/hardware/adapters#upconverter>

All Theremino applications can interact with Theremino SDR. The audio signal can even be decoded (for example with Theremino SignalDecoder) and one can receive and send commands through the slots. The interactions include the frequency setting, volume and operation mode (FM, AM, SSB, CW etc ..), as well as the possibility of controlling other equipment with the received signals.

## What if Theremino SDR does not start

DotNet could have been not installed (to save memory on the disk). In these cases Theremino SDR does not start, and it is shown an error message similar to the following:



If the problem is DotNet, install this:

[http://www.theremino.com/files/dotnetfx35SP1\\_ENG.exe](http://www.theremino.com/files/dotnetfx35SP1_ENG.exe) (Local copy) **(Note 1)**

**(Note 1)** Unfortunately Microsoft frequently move files, and hides installers "offline" to promote those "online" (which sometimes does not contain any files). So, to simplify searches, we made some local copies.

Install these components without fear, they are signed by Microsoft and can not damage the system. The installation of Microsoft programs are smart, if something is wrong they do not install.

Other useful information on this page:

<http://www.theremino.com/downloads/notes-on-software>

### If you are unable to start with "Run"

In this case probably the handset driver is not installed, or it is not the right one. Read the instructions for the receiver in Appendix 1, and also the next page, which explains how to install the driver with ZADIG:  
[Appendix 1 - The receiver RTL2832U](#)

If this is not enough to run the receiver and whenever you press Run you get an error, then probably the receiver does not work, or it is not connected to the USB or the Windows USB system crashed. Try disconnecting the receiver and reconnect it, and be careful if you hear the sound indicating the connection. As a last test you can try to restart Windows, to change the USB cable and to replace RTL with another receiver.

# First Setup to start hearing something

## Without Theremino Upconverter

- Connect the receiver to the USB RTL and its small standard antenna. And press the "Run" button in the upper right. If you can not activate it, follow the instructions on the previous page.
- Check the first top panel "Receiver", the "Converter shift" box must be disabled.
- Raise "Tuner Gain" (right vertical cursor) to three quarters (values from 30 to 40)
- Slide the left commands column, till down, and open the "Frequency list"
- Check that the "Frequency list" is "all\_bands" and eventually load it with "Load"
- Scroll down the "Frequency list" until almost the end and click on the FM band lines, until you hear a commercial station.
- Close the "Zoom" (drag the slider to zero), and search for other stations in the band from 88 to 108 MHz
- To move in steps of 100 KHz, position the cursor on the big indicator of the rate that is at the bottom, the first digit after the decimal point, and use the mouse wheel.
- Or, set "Snap to 100 KHz" in "Demodulation" panel and then use the scroll wheel or mouse on the spectrum analysis window.
- Without Theremino upconverter, in addition to FM stations, the only other readily receivable broadcasts are the weather sensors at 433 MHz or 866 MHz. Go about in-band, fully close the Zoom around zero, enlarge BW maximum (24 KHz) and wait for a minute. The weather sensors transmit about every minute and you should see their short tracks in the top window. Then you place the cursor on the track and wait another minute. You should feel the sensors of all the neighbors, up to several hundred meters.

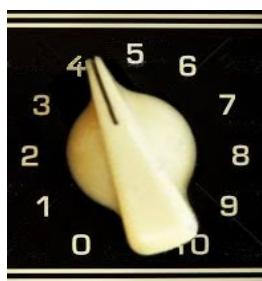
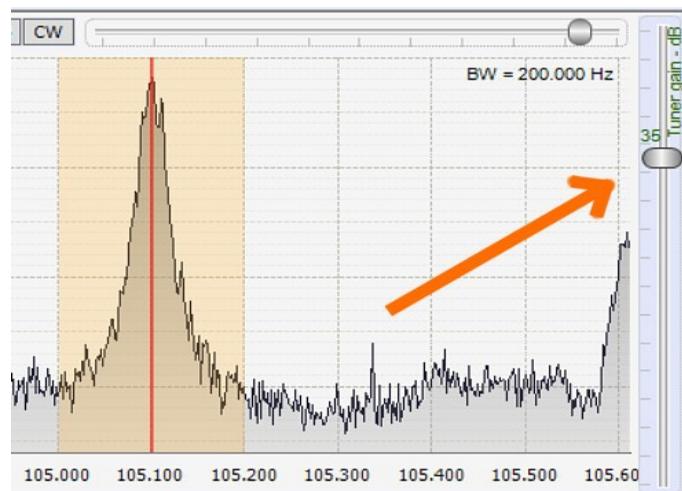
## With Theremino Upconverter

- Connect the RTL receiver and the upconverter to the Antenna with a shielded cable, instead of the Antenna you can use a wire 10 meters long. Antenna or wire should be connected to the cable end, outdoors. If the antenna is in the house you will not hear virtually nothing.
- Press the "Run" button in the upper right. If it does not work, follow the instructions on the previous page.
- Check the first top panel "Receiver", the "Converter shift" box is enabled and the number to the right should be -125.000.000
- Slide the left commands column, till down, and open the "Frequency list"
- Check that the "Frequency list" is "all\_bands" and eventually load it with "Load"
- Set "Tuner Gain" (right vertical cursor) low enough (values from 5 to 15)
- Adjust the antenna gain potentiometer, potentiometer or attenuator, halfway.
- Scroll through all the rows of the frequency list, starting at the top, with the down arrow key on the keyboard, and you should be able to hear numerous broadcasts.
- A major band, good for practice, it is the band of 40 meters. Find the line "40 meters VOICE - HAM", then click the line "Band 7.050.000 7.200.000" to set the band. And finally click on the line "7.050.000 LSB 3K VOICE Start" to set the type of modulation (LSB) and the bandwidth (3 KHz). At this point you can start to recognize the LSB type carriers, which have characteristic lines in the upper window. You can select the signals with the mouse and hit them with the wheel. It may be useful to set one "SnapTo = 500 Hz".
- Consider that there are better days and worse. At times you do not hear anything and maybe an hour later you can hear hundreds of conversations. Saturdays and Sundays are the best days.

# Adjust the gain controls

If you are using only the RTL receiver (without upconverter), then there is little to be adjusted.

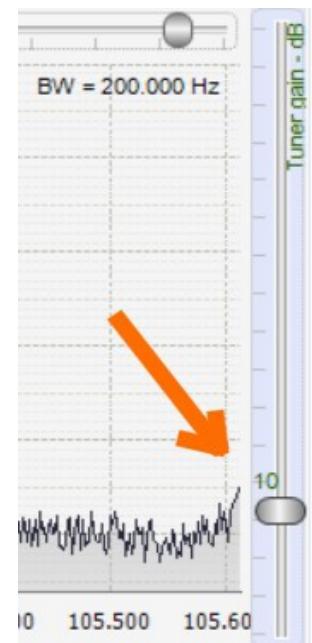
Set the "Tuner Gain" slider around three quarters of the range and you get the best adjustment for almost all signals.



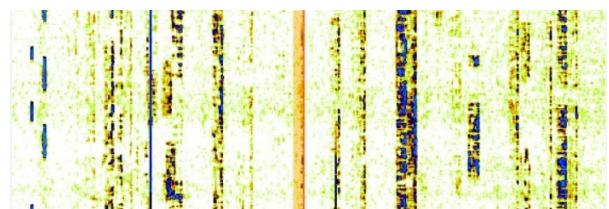
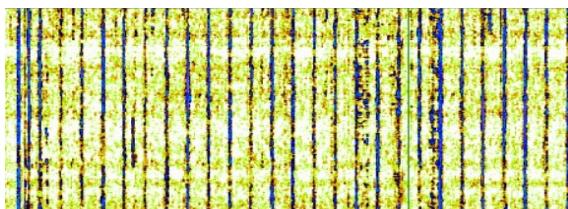
When you are using the upconverter, and especially in the amateur bands, you must carefully adjust both the input attenuation controls that the "Tuner Gain", in order to work on the limit of intermodulation and achieve the maximum sensitivity, to catch weak signals.

Depending on how the receiver is built on the front panel there may be a regulator adjuster on the antenna sensitivity, or a signal attenuator potentiometer (or even both - see the diagram of [Theremino upconverter](#)).

Normally, the potentiometers are set about halfway and the Tuner Gain around the value 10. In some days you can raise these adjustments, while at other times, when the disturbances are stronger, it is better to lower them.



To obtain the best adjustment, set the controls up, one at a time, until to see the lines produced by intermodulation, after that you go back with the controls just a little.



In the left image you see the lines of intermodulation, that appear if you rise the controls too much. Instead in the right image you can see how the signals look like (in this case LSB transmissions on the 40 meters), when the gain controls and attenuation are well regulated.

# The ToolBar commands



## Load

This command loads a list of frequencies. There are some example lists, but everyone can edit or modify them adding other stations and bands.

## Save As

This command saves the frequency list with a new name. It is only to make new lists, usually not used. The list currently in use is automatically saved if changed.

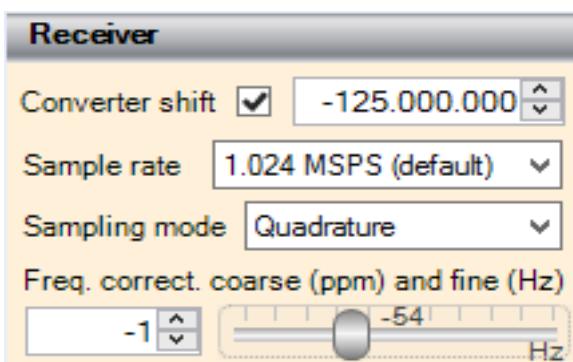
## Docs

The Docs folder includes instruction files, some folders with lists of stations, and other useful files.

## Stop / Run

With this command the application is paused, it becomes “silent” and does not consume anymore processor time. If you want to reduce the CPU consumption, while keeping the application running, then not use the Stop command, but minimize the application. When the application is minimized it continues to decode the signals and update the audio and the communication signals with the slot. However when "Stopped" it does nothing.

# The "Receiver" Panel



## Converter shift

This is the frequency shift caused by the UpConverter. If, for example, the UpConverter quartz is of 125 Mhz, then you must set -125.000.000. It is a negative number to subtract the 125 MHz that are summed by the converter.

## Sample rate

This command determines the total bandwidth. This is not the bandwidth of the signal that is being received, but the total width of the spectrum analysis, which includes more signals, all of them simultaneously visible. You can raise the sampling rate up to 2.56 MSPS (corresponding to a window of 2.56 MHz) and you get the advantage of seeing more signals simultaneously. But there are drawbacks: the PC processor works harder and the quality of the signal get worse. So it is advisable to keep it at 1.024 MSPS.

## Sampling mode

Since version 4.6 we have added the ability to choose between "Quadrature", "Direct sampling I" and "Direct sampling Q". Read the instructions to use the new versions of RTL-SDR Version 3 in the section "Receiving shortwave without upconverter" of the [download page](#).

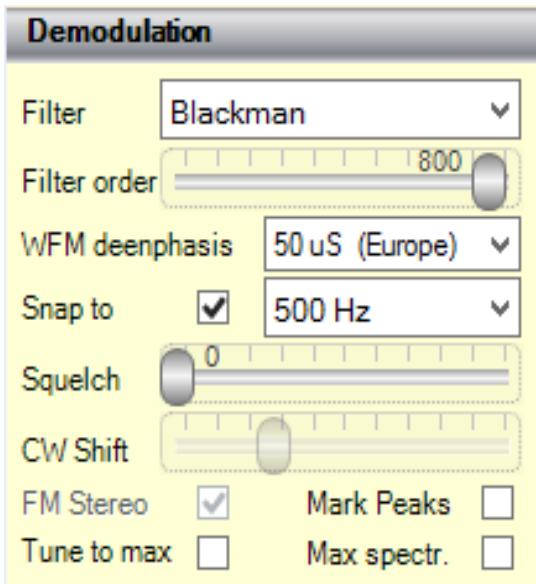
## Frequency correction

For the coarse frequency correction we used the measurement unit of PPM (parts per million) because it is a common practice across the SDR software. But it is not significant unit without the frequency at which it is applied. And this frequency is not the signal frequency, but the frequency of the crystal inside the receiver. Therefore, since the crystal runs at 28.8 MHz, a PPM is equivalent to 28.8 Hz. Note, however, that in practice one PPM can cause a displacement of about 120 Hz, then the frequency of the quartz in the tuner is multiplied by four, before making the conversion, which itself it is a trivial subtraction between two numbers.

To make the correction, center a sample station, for example DCF77 or DCF49 or DCF39 (during this operation is a good idea increasing to 32.768 the resolution of spectrum analysis, but after you must remember to reduce it, otherwise the CPU works too much)

If you are using an SDR model selected from among those stable in temperature, then these settings are good “forever”, otherwise you have to set them often, especially when listening to broadcasts in LSB and USB.

# The "Demodulation" panel



This panel acts differently than other SDR applications.

Other SDR applications, when you change the modulation type, change the values of Filter, Snap, Squelch and Shift. But these "default" values are not appropriate to all stations, with the same type of modulation. So in Theremino SDR each station may have its individual values.

In Theremino SDR this panel is entirely manual (the values do not change when the operating modes are modified). The individual values of the stations are set with the commands of the "Frequency List".

**Filter** - Filter type, to be used in the Fourier transform, for the reception of signals. Usually we use the Blackman, but there are big differences between the filters.

**Filter order** - This value sets the steepness of the filter sides. With low values (10 to 50), the transition between the passband and the out of band area occurs gradually. With high values (100 to 500), the transition is abrupt. The effect of this adjustment is audible in the audio signal. Adjustment is made for a pleasant and intelligible audio. Very high values can cause instability of AGC or less clean listening.

**WFM DEENPHASIS** - Commercial broadcasting on the FM band (88 to 108 MHz) amplifies the high frequency band. An exaltation in transmission (preemphasis), allows for reductions in reception and reduce at the same time, the ever-present breath on the acute frequencies. In the United States it is using a constant different time than in Europe. Selecting "USA" or "Europe", you get the highest quality of listening to the music.

**Snap to** - Determines the minimum spacing between frequencies, when using the mouse to select them.

**squelch** - It is used to mute the receiver when the signal is too weak or too noisy. The threshold value is quite critical and must be adjusted individually, for each band or at each station.

**CW Shift** - This is the basic tone, for the reception of Morse signals. You set the frequency that you believe more pleasant. Usually between 500 and 1000 Hz.

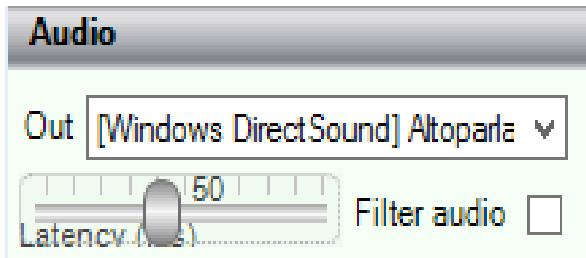
**FM Stereo** - Enable stereo reception of WFM stations (classical FM band).

**Mark Peaks** - It may be useful to highlight the spectrum analyzer stations.

**Tune to max** - Automatic tuning to the station with the strongest signal. They are selected only stations on the visible area in spectrum analysis. It is used only for special receptions, such as remote controls and the 433 weather sensors and 866 Mhz,

**Max spectr.** - The maximum level reached by the signals in the spectrum analysis is shown with a line in light green color. To reset it, disable and re-enable this control.

# The audio panel



**out** - Preferably select a type DirectSound output. Asio could be better but sometimes it does not work. An interesting possibility is the "Virtual Cable" ([Note 1](#)), To send the signal to other software directly.

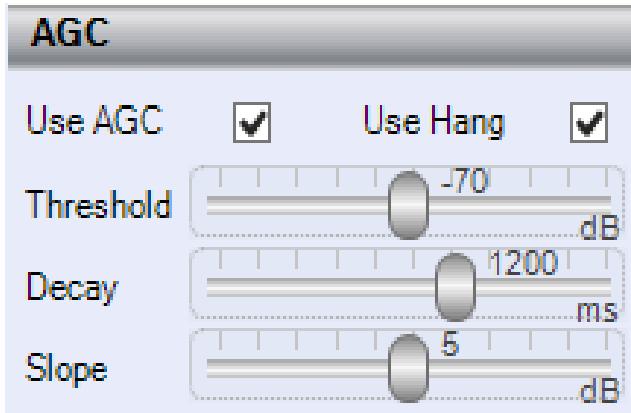
**Latency** - This is the delay time between the arrival of the signals and the production of the audio signal. It is 'better to keep it low, but if too low you can hear some. On some computers a level below 100 ms can be reached, while with others you have to raise it, even up to half a second and beyond.

**Audio Filter** - It is advisable to keep it enabled. Filtering the audio you get a double filtering, the first is on the radio frequency signal and the second on the audio signal. Both filters have the same bandwidth (determined by "Filter Width"). This second filter helps to reduce hiss and whistles, which are often present in the medium wave and short wave.

## [\(Note 1\)](#) The Virtual Cable

The Virtual Cable (explained in [Appendix 4 - Decode signals](#)) Transfers the signal directly from one application to another without going through your sound card. The communication is digital, independent of other Windows sounds and mixer levels used for other sounds. A further advantage is the ability to transfer signals silently (without hearing them in the speakers).

# The AGC panel



Unlike other SDR software, this is a real AGC, ie it pump-up weak signals.

Other SDR, while calling AGC, use it to "limit" the strong signals (but in this case should be called "limiter").

**Use AGC** - Enabling or disabling the total AGC

**Use Hang** - Enabling "Hang", the response time changes slightly and may be better for some SSB and Morse signals.

**Threshold (dB)** - Threshold of AGC in decibels. The signals with carrier below this level are not amplified. Instead all signals, above this level, are amplified up to the level of the strongest signals.

**Decay (ms)** - Response time in milliseconds. high value delaying the intervention, too low cause an obvious and annoying effect of "pumping".

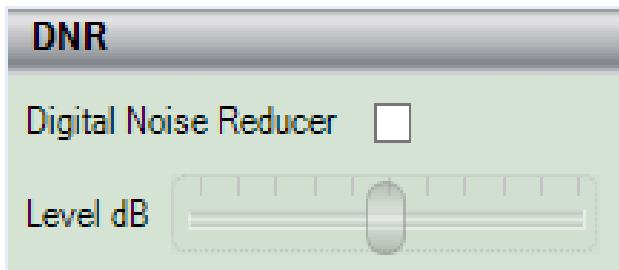
**Slope** - Gradient of the straight line of gain correction. Usually it is better to set it at 5.

The values shown in this panel are adequate in most cases. In special cases (such as decoding of digital data) you can set these values individually for each station, with controls of the Frequency List.

The commands to use in Frequency List are:

- ◆ **AgcOFF**
- ◆ **UseHang**
- ◆ **AgcThreshold nn** (where n is an integer from 0 to -160)
- ◆ **AgcDecay ms** (where nn is an integer from 10 to 2000)
- ◆ **AgcSlope n** (where n is an integer from 0 to 10)

# The DNR Panel



The DNR performs the spectrum analysis of the audio signal, removes noise and then reconstructs the signal with the inverse function ([Note 1](#))

**Digital Noise Reducer** - Enable or disable the DNR

**Level (dB)** - Threshold of DNR in decibels. The noise below this level are completely eliminated.

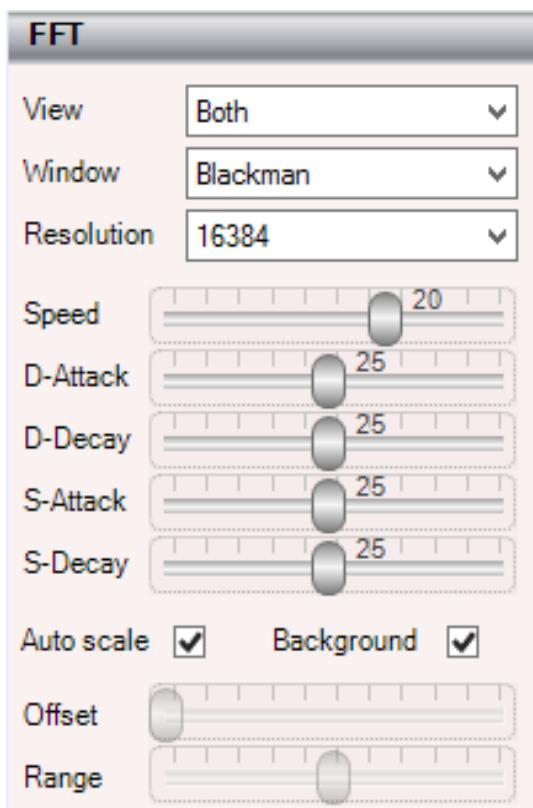
## (Note 1)

The spectrum analysis, direct and inverse, are the operations that make the SDR receivers better than the classics receivers. These functions were impossible only with hardware, even for the most expensive receivers.

Another feature impossible to achieve, was the variable bandwidth with steep fronts. Something similar was obtained with lattice filters (the famous expensive ceramic filters Collins) who were limited to a few frequencies, one for each filter. A good receiver contained three or four at the most by 6000 Hz, 3200 Hz, 2700 Hz and 800 Hz.

Realize really tight filters (eg 10 Hz) was impossible. And the filtering quality was rough (form factor was not perfectly squared).

# The FFT panel



**View** - With this command you choose whether to display only the spectrum analyzer, only the PaperDrum (paper drum) or both.

**Window** - window type to be used during the analysis spectrum sampling. The differences between the various types are variations of the amplitude of the lines and the intensity of the noise floor. These are small differences, usually the BlackmanHarris4 is used, which has balanced performance.

**Resolution** - Increasing the resolution, the lines appear more defined, so it would be better to set it at maximum, but actually the values 8192 or 16384 are usually used, to avoid overload the processor.

**Speed** - scrolling speed of PaperDrum and spectrum analyzer update. Not to set at maximum to avoid overload the processor.

**D-Attack, D-Decay** - These are the rise and fall times of the colors in "Paper Drum". Normally set halfway.

**S-Attack, S-Decay** - These are the rise and fall times of the graph, the spectrum analyzer. Normally set halfway.

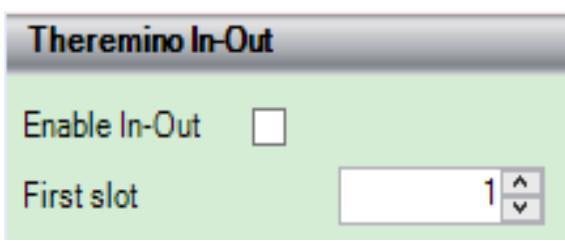
**Auto scale** - Enabling Auto-scale. Auto range maintains "Paper Drum" and "Spectrum Analyzer" in the best conditions of visibility. The values of "offset" and "Range" are continuously updated, based on the signals. You should keep this option always enabled.

**background** - By enabling this option, the bottom of the spectrum analysis is filled with gray.

**offset** - If you do not use automatic scaling, this control adjusts the vertical position of the graph.

**range** - If you do not use automatic scaling, this control adjusts the vertical amplitude of the graph.

# The "Theremino In-Out" Panel



With these commands, you enable communication with the Theremino system slot and determine the first slot in use.

Starting from this first slot, a number of consecutive slots, is used for input and output, according to the following list:

## INPUTS (assumes that First Slot is set to the value "1")

**Slot 1** - Setting the frequency (in KHz and fractions). The frequency change is performed every time the value of this slot changes. The applications of Theremino system can write a reception frequency in this slot. The answer is very fast, so it can simulate true tuning knobs, which respond exactly as the knobs of the old radio. Using a potentiometer and an ADC, the tuning will be limited to a band of frequencies. Otherwise you might get a tune continues, using a Pin Encoder type and economic Encoder 24 steps per revolution, found on eBay.

**Slot 2** - Volume setting. The range is from 0 to 1000 and the response is logarithmic, so similar to a real volume potentiometer.

**Slot 3** - modulation type. The values 0 to 6 set the WFM types, NFM, AM, USB, LSB, DSB and CW. When you change the type of modulation is also set for each, its default bandwidth.

**Slot 4** - Bandwidth in Hz. After setting the modulation type you can touch up your bandwidth with this Slot.

**Slot 5** - Line of Frequency-List to set. This is a very powerful command. A row of Frequency-List can specify different values, such as frequency, bandwidth, modulation type, amount of squelch and DNR. In addition, the "Band" lines can also set the "Zoom" cursor and the center frequency of the band. You can then create specific lists, with predispositions of stations and modes and select them easily with other applications of Theremino system.

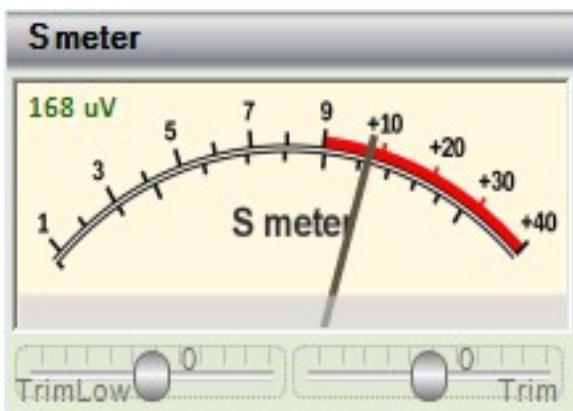
## OUTPUT (assumes that First Slot is set to the value "1")

**Slot 11** - Power of the tuned signal. The signal is typical of S-Meter, with logarithmic scale. The values from 0 to 1000 represent approximately the values S0 to S9 + 40.

**Slot 12** - Power of the strongest signal, in the visible range of the spectrum analyzer. The power is measured in decibels, with the same scale decibel visible in the spectrum analyzer window. A value of 1000 in the output slots is 0 dB (the maximum of the scale of the spectrum analyzer), while the value zero is -100 dB.

**Slot 13** - Frequency (in KHz and fractions) of the strongest signal, in the visible range of the spectrum analyzer.

# The S-meter measuring instrument



The S-Meter is useful for checking the strength of the received signals. Without it, and with the AGC which makes all the same audio signals, do not appreciate the differences in amplitude, between the weak signals and strong ones.

You can not make an s-meter setting that is still valid. Many variables affect the calibration, the receiver sensitivity RTL and its gain settings, the gain of the antenna and the gain adjustment of the active antenna. Each of these adjustments affects the total gain and also on the response curve when the frequency changes.

Normally you just a rough indication, which is obtained with the two calibration trimmers halfway (zero value).

If you change the "Tuner Gain" it is made an internal compensation and this compensation can generate a little intuitive behavior. With some adjustments, raising the "Tuner gain", the value shown by the s-meter decreases. This is due to the fact that the compensation is greater than the signal is actually amplified, due to the limitations and saturations in the receiver.

The value marked by the S-meter may help to adjust the "Tuner gain" and get the maximum ratio between signal and noise.

## accurate calibration of the S-Meter

Calibrate S-Meter it can be useful to make measurements, for example to compare antennas and antenna amplifiers.

With a signal generator and an attenuator, sending a strong signal (10 to 100 uV effective) and adjust the right trimmer to match the size of this table. Then it sends a weak signal (less than microvolts) and will adjust the start of scale with the left trimmer.

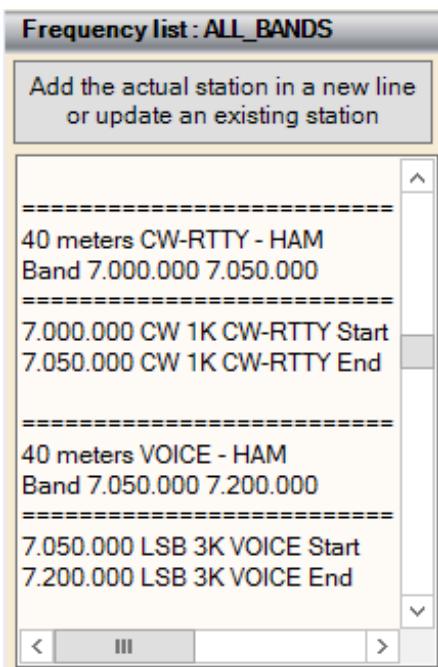
Tensions in the table, are effective or RMS volts (which are equivalent to sinusoidal signals, the only ones that interest us).

If you measure the peak-to-peak voltage, for example with an oscilloscope, in order to obtain the effective voltage, multiply by 0:35.

Signal strength	related intensity	dBm	Received voltage below 30 MHz	Received voltage above 30 MHz
S9 + 40	40 dB	-33	5.0 mV	500 microvolts
S9 + 30	30 dB	-43	1.6 mV	160 microvolts
S9 + 20	20 dB	-53	500 microvolts	50 microvolts
S9 + 10	10 dB	-63	160 microvolts	16 microvolts
S9	0 dB	-73	50 microvolts	5.0 microvolts
S8	-6 dB	-79	25 microvolts	2.5 microvolts
S7	-12 dB	-85	13 microvolts	1.3 microvolts
S6	-18 dB	-91	6.3 microvolts	630 nV
S5	-24 dB	-97	3.2 microvolts	320 nV
S4	-30 dB	-103	1.6 microvolts	160 nV
S3	-36 dB	-109	0.79 microvolts	79 nV
S2	-42 dB	-115	00:40 microvolts	40 nV
S1	-48 dB	-121	microvolts 00:20	20 nV

CAUTION: The calibration remains valid only if you keep the gain constant adjustments (software and antenna) and only for frequencies near the calibration.

# The Frequency List



The "Frequency List" are plain text, easy to edit and understand, one of the most clever innovations of this application. You can write about anything, and it will be easy to expand them with commands that I can not even imagine.

With this system you can collect hundreds of stations, edit, browse through them and tune them quickly.

The stations are added by writing the text, or you press the groping "Add the actual station ...", to add the station that is currently tuned.

When you add stations manually it is good writing in order of frequency. So the automatic insertion will know where to insert new stations.

## Basic Operation

For each band you write a name to identify it. In the following line you write Analyzer band limits of the spectrum, and in the following lines the comments and any special commands, valid for all stations of that band.

Then, in each row, you write a single station, starting with the reception frequency, continuing with the type of demodulation to use, the bandwidth, the name and comments.

It is not necessary to list all the stations, one by one, of all possible channels of a band, but it is sufficient to write some, that will be the sample for the common features. Then the tuning of individual stations is performed with the mouse, and the mouse wheel, on the spectrum analyzer.

## Tune stations and execute commands

The stations tune in by clicking with the left mouse button, on the train line.

The commands, and even the band limits, are performed by clicking on the command line.

With the up and down arrows on the keyboard, they slide the rows and performing as you scroll.

With the mouse wheel you can scroll through the list, without performing individual lines.

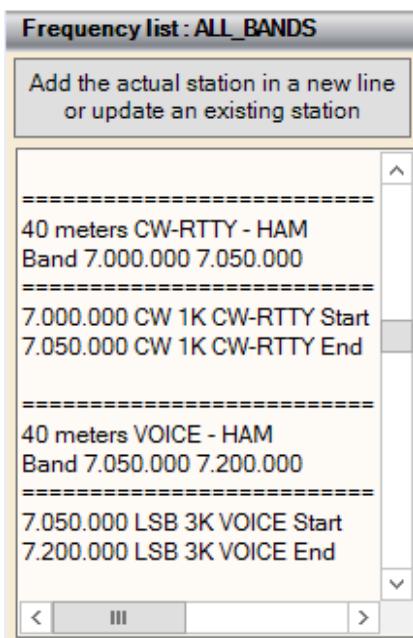
If you hold down the CTRL key, the lines are executed, even by scrolling with the wheel.

The rows can be performed also on further applications of the system ThereminoSee page 14.

## Save and restore "Frequency list"

The lists are loaded and saved with the buttons "Load" and "Save as". I am already prepared a number of lists, but you can create your own. To create their own lists, you may want to save existing ones, with a different name, and then change them at will. When you change the list currently in use, it is not necessary to save it. Any change is always saved immediately, as you write.

# The Frequency List commands



Each line of text can contain one or more commands.

Usually in the rows of the title you write the name and the band limits (minimum and maximum frequency).

Just below, but always in the title, you write the special commands like "FilterOrder", " Snap ", " Squelch " and " AGC " that are used in common for all stations on the band.

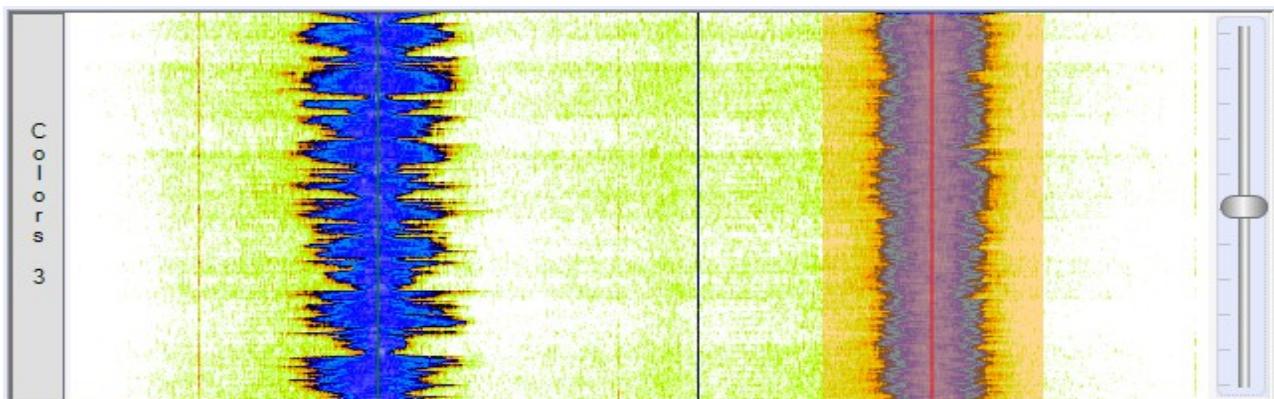
Then they write, one by one, the rows of individual stations with the reception frequency, type of demodulation, bandwidth, name and comments.

In this example you have set only two stations per band. These stations are used to set the receive mode and the bandwidth. Each station will then be tuned in on the spectrum analyzer, with the Mouse.

Example command	of Minimum maximum	and Function
Bands 30,000 120,000	10,000 up	of the visible frequency band limits. This command is executed by changing the Zoom position. The maximum bandwidth can not exceed one or two Mega Hertz, depending on how it is set to the "Sample rate" in the "Receiver" panel
7,150,000 LSB 3K	10,000 up and from 5 Hz to 24 KHz	the tuning frequency, the receiving mode and bandwidth of the single band station
FilterOrder 500	10 to 999	filter order. Explained in "Demodulation" panel on page 9
snap 1000	1 to 500000	Minimum spacing between frequencies, when you tune in with the Mouse
squelch On		Enabling the "Squelch"
squelch Off		Disabling the "Squelch"
squelch 70	from 0 to 100	level of intervention of the "Squelch"
aGC On		Enabling the "AGC"
aGC Off		Disabling the "AGC"
Agc Hang On		how enabling "Hang" the "AGC"
Agc Hang Off		how disabling "Hang" the "AGC"
AGC Threshold 75	from 0 to 160	level of intervention of the "AGC"
Agc Decay 100	10 to 2000	Recovery time of the "AGC" (in milliseconds)
Agc Slope 0	from 0 to 10	Slope of intervention of the "AGC" (intervention force)

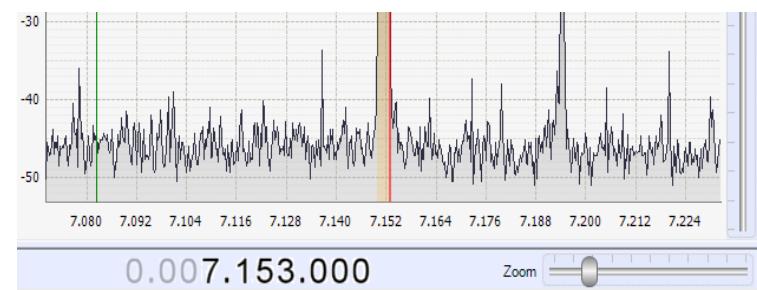
*Not all commands are implemented in the current version of Theremino SDR. It also plans to add new commands, in the next versions.*

# The "Paper drum"

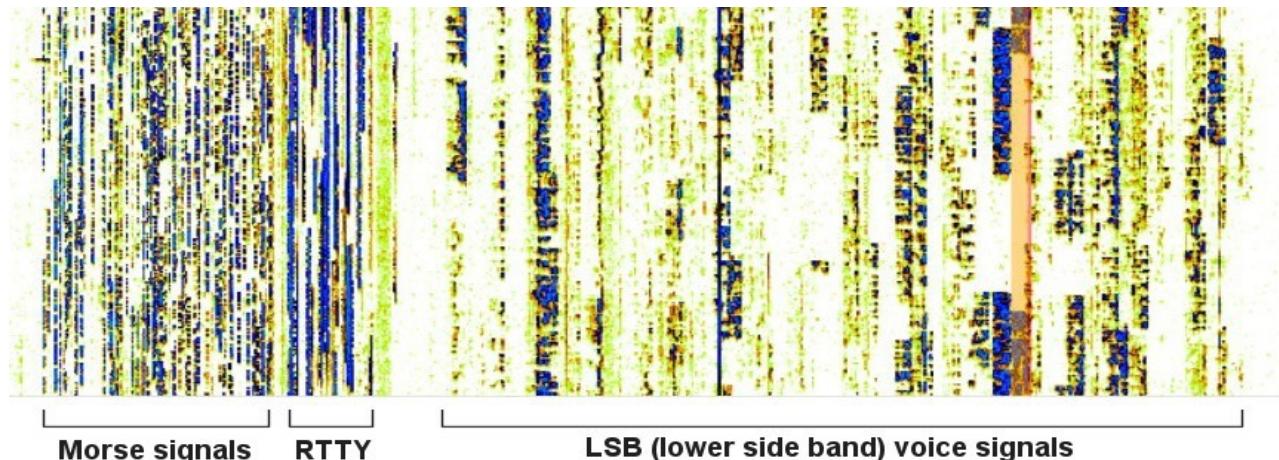


The Paper Drum, in Italian "Adding Machine", takes its name from the old recorders who were writing with pens and ink on a coated paper roll.

Other SDR do go down a waterfall "Waterfall" from below, by moving the top analyzer, in a little ergonomic position. Instead Theremino SDR drives up the traces of Paper Drum from the tips of the signals, without interfering with the lower part, which remains reserved to the frequency scale. In this way the frequency of the indicator, and the frequency scale, are close together, and the adjustments are easier.



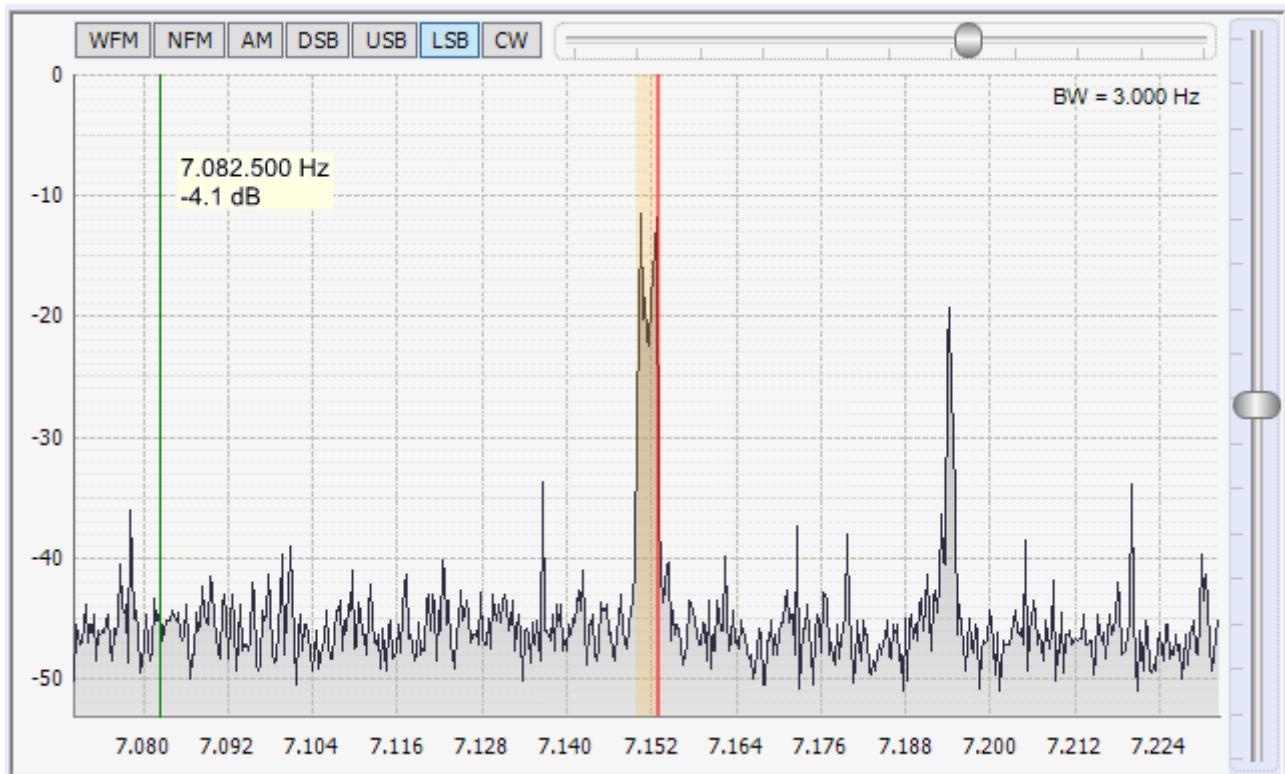
The shape of the signals over time is a great help to recognize them. A trained eye can spot the interesting signals, even if weak and in the midst of disorder. When you find the right signal will click on it to tune it.



In this picture you can see three types of signals, among the most characteristic of the 40 meter band. To the left is the area reserved for Morse signals, which are easily recognizable because they are made from dots and lines. In the center you can see the transmission of teletype machines, which are continuous lines, a bit wider. Finally, in the large area to the right, you see the voice signals in LSB.

The different width is due to the fact that the Morse signals occupy a narrow band (tens of Hz), and the most wide teleprinters (hundreds of Hz), and the even greater voice signals (About 3000 Hz).

# The spectrum analyzer



The spectrum analyzer area is the center of the SDR application. All frequently used commands are concentrated here. There are buttons for "Reception Modes", the cursor of the "Bandwidth" and that the "Tuner Gain".

**WFM, NFM, AM, DSB, USB, LSB, CW - Reception modes** - These buttons choose the type of demodulation. The details are on the next page.

**Filter width - the reception band width** - This parameter should be adjusted depending on the type of signal that is received. Typically approximately with the following values:

200 KHz for WFM

10 KHz for NFM

from 3 to 20 KHz for AM

from 2 to 3 KHz for DSB, LSB and USB

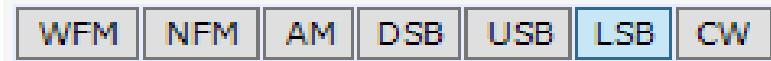
from 10 Hz to 1 kHz for CW

**Gain Tuner - Tuner Gain** - For best results, He rises this parameter up to sprouting lines of inter-modulation and then is lowered, to eliminate leakage. Usually it is adjusted from ten to twenty, but in times of strong propagation and at night you may need to lower it even up to a minimum. If you do not use the Up-Converter it could also raise to thirty and in certain cases also to the maximum.

To achieve optimum reception of weak signals and minimum interference from the inter-modulation of commercial stations, also adjust the antenna gain or antenna attenuator (if present). See: [Appendix 2 - The Theremino upconverter](#).

# The receive modes

These are the classic ways of demodulation of the radio reception. It's important to note all of which are audio signals, no digital signals. ([Note 1](#))



**WFM** - Receipt of commercial stations in the FM band ([Note 2](#))

**NFM** - Frequency modulation with narrow band (a few special stations).

**AM** - Amplitude modulation (the classic stations of medium and short wave).

**DSB** - "Double Side Band" - Reception of the upper and lower sidebands.

**USB** - "Upper Side Band" - Receiving the upper sideband.

**LSB** - "Lower Side Band" - Reception of the lower sideband.

**CW** - Emissions Receiving telegraph FSK, RTTY and Morse code.

## ([Note 1](#))

The decoding of digital signals, will be performed by sending the received signal to a dedicated application. With the "Theremino SignalDecoder" you receive signals in Morse code, the signals of car alarms, open gates and meteorological radio-transmitters (For example those of Oregon and the like). With other applications are received teletypes, weather maps, and other digital signals. See pages: [Appendix 4 - Decode signals](#)

They exclude computer signals: BlueTooth, WiFi and ZigBee, For the following reasons:

- They are two-way and need a two-way protocol.
- They use frequencies (2.4 GHz) that are outside the admissible range.
- There are already, adapters simple and economic, to be connected to the USB.

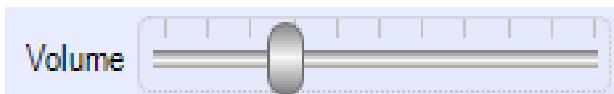
**([Note 2](#))** The FM band (frequency modulation) is from 88 to 108 MHz and includes many stations that broadcast in Stereo, with great power. Practically are the only stations receivable with antenna. To get everything else would take appropriate external antennas. A special case are the weather transmitters and remote controls 433 and 866 MHz, which are received well, even at a great distance, with the small 12-centimeter antenna.

## Tuning adjustments with the mouse

Both in the window of the "Paper Drum" or as the "Spectrum Analyzer", you can tune into stations with the mouse, in several ways:

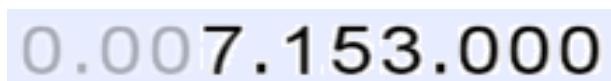
- Click the left button to tune in stations (a bit 'on the right, if they are LSB, or left, if they are USB)
- Hold down the button and move the mouse, to move the tuning point.
- Click the left button on the frequency scale down and move the mouse to move the entire frequency band.
- If you use the right instead of the left, as well as move the frequency scale, also move the stations.
- With the mouse wheel, adjusting the frequency in discrete steps (as adjusted "SnapTo" of "Demodulation" panel)
- If you hold down the Ctrl key, then the mouse wheel adjusts the frequency in fixed steps of 100 Hz. This is for the frequency fine adjustments in the DSB, LSB, USB and CW.

# Volume, frequency and Zoom controls



The volume there is little to say, everyone knows how to use it. But there are hidden properties, making it the best volume of other SDR applications controls.

First, the adjustment is logarithmic, as in real receivers than once. And then it contains a limitation algorithm, which allows to lift it at will, with each signal, without ever distort and produce unpleasant noises. Those who have tried other SDR applications can understand what is useful.



This seems only a number, but hides four operating modes.

1. You can write a full frequency with the keyboard. It moves the mouse cursor to the first digit to be written (without clicking) and then writes all the frequency using the keypad numbers.
2. With the cursor on a figure you click the top half, to increase it, or the lower half to decrease it.
3. Clicking the right button on a figure the resets and resets all the digits on his right.
4. When the cursor of the mouse is on a figure you can also use the mouse wheel to change it.
5. After selecting a number you can use the up and down arrows on the keyboard to edit it.

With the mouse wheel you get a convenient adjustment and similar to that of the radio hardware. But with the advantage of being able to adjust in steps of one, ten or even hundred Hertz of thousands of Hertz, depending on the digit on which the cursor is placed.



Control "Zoom" sets the width of the visible area of the spectrum analyzer.

For the amateur bands it is recommended to set the visible band, with command lines "Band" of "Frequency List" and then to maintain visible all the bandwidth by not using the Zoom, except in special cases.

Raising the Zoom enlarges the area around one of the currently tuned station.

With the Zoom to a minimum, you see the maximum possible bandwidth. The maximum width can be from 0.9 to 2.5 MHz, depending on how it is set the "Sample Rate" in the "Receiver" panel.

## Appendix 1 - The receiver RTL2832U

Originally studied for television and FM radio, these receivers can receive frequencies from 25 MHz to 1750 MHz.

The tuner chip can vary (R820T, R820T2, R828D, E4000, FC0012, FC0013, FC2580), but to work with Theremino SDR, must contain the chip-set **RTL2832U**, check that it is specified **RTL2832U** (with the "U" at the end) before you buy. For a list of all compatible devices to read [This Page](#).



This model can be purchased on eBay, for 8 Euros, shipping included, (from China with some travel week). If you do not want to wait you can find it in for a few more euros, already in Europe.



Other models of various shapes, even very small, are all more expensive. Some do not contain the tuner chips R820T or R820T2 or R828D and therefore do not

cover the full band from 25 to 1750 MHz. Some start at 52 Mhz and may work with Theremino upconverter. Others start at 146 MHz and do not go right (you can not connect the upconverter to receive long-wave medium and short and amateur bands).



If possible it is better to buy the models with the tuner chip R820T2, which is slightly more sensitive. Attention to written "820T2" with "2" final. They are also found on eBay for 8 Euro (from China) and 15 euros (France). Go to eBay and look for: "RTL2832U R820T2"



There are also more expensive models (25 to 50 euros), with quartz which makes the perfectly stable reception frequency. With these models They receive SSB transmissions, without ever touching up rate.

try "R820T2 RTL2832U 1PPM TCXO ", or" NooElec Mini 2+ 0.5ppm TCXO "on Google and eBay.

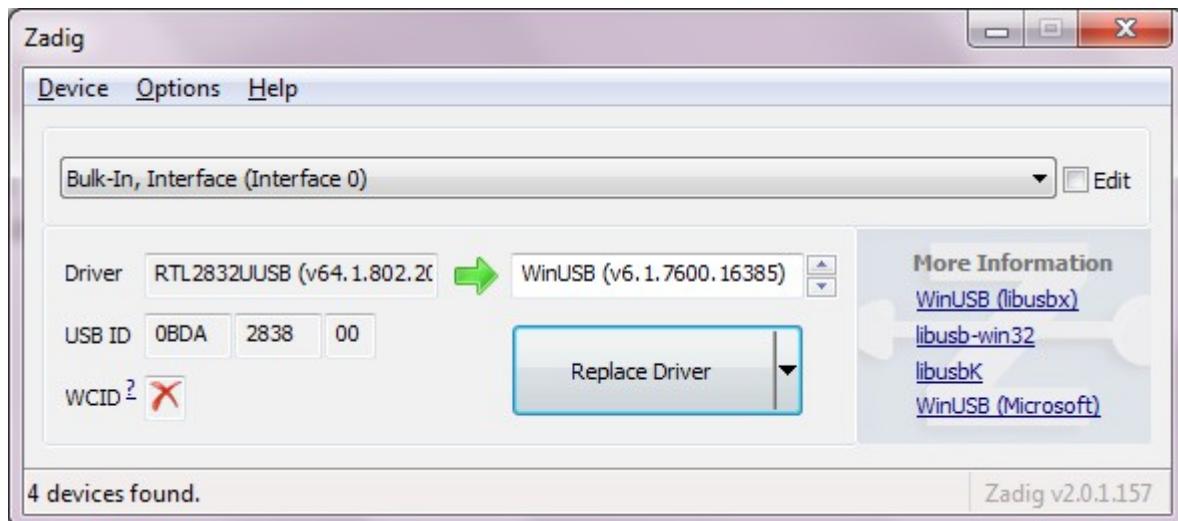


The new [RTL-SDR V3](#) contains two major improvements. (1) You can receive the short waves (up to 500 KHz) without up-converter and with slightly lower but comparable performance. (2) You can feed the active antenna (adding 3 components). Read the notes on the Theremino SDR [download page](#).

# The receiver driver and Zadig

When you connect the receiver to the USB port, Windows will install a generic driver suitable for receiving TV and FM radio, with special programs, but not suitable for SDR applications.

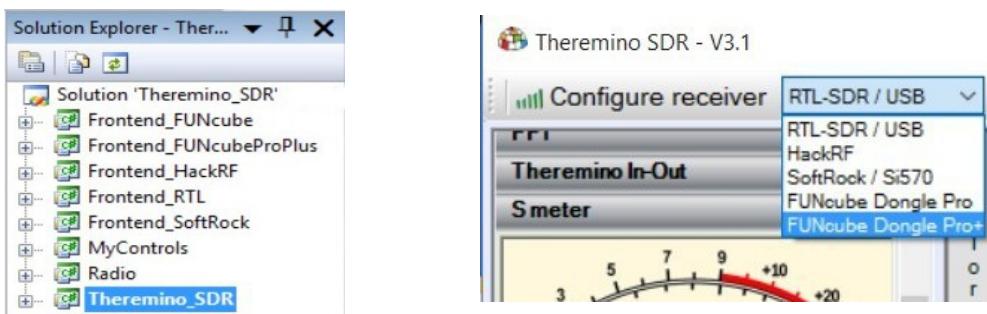
To work with Thermino SDR, the RTL receiver requires a special driver that installs with the application "Zadig".



- ◆ Zadig download from here: [http://www.theremino.com/wp-content/uploads/files/zadig\\_2.1.1.zip](http://www.theremino.com/wp-content/uploads/files/zadig_2.1.1.zip)
- ◆ Then you press "Options" / "Show all devices"
- ◆ You choose "Bulk-In, Interface 0" (sometimes called "... RTL ...")
- ◆ Sure you have "WinUSB" to the right of the green arrow.
- ◆ And finally it is replacing the driver, by pressing the button "Replace Driver"

# Other SDR applications

The first versions of Theremino SDR were written in VbNet, but in the years 2010-2014 we have translated the code to CSharp to align with the other Open Source applications. We then implemented the dynamic connection of the FrontEnd and the ability to connect the "FUNcube", "FUNcube Pro Plus", "HackRF" and "SoftRock" receivers, and also the Plugins developed by users.



*In these images you see that up to version 3.1 you could connect several FrontEnd*

Our intention was also to facilitate the software exchange between our application and other similar applications. So we made the code similar to that of other SDR applications, mainly SDRSharp, which in those years was Open Source too. Early versions can be downloaded today still [Open Source from here](#) or in alternative (in the case is removed) [from WebArchive site](#).

We then coordinated with SDRSharp in full compliance with the Open Source spirit and the license included in its source: Copyright (c) 2012 Youssef Touil and other contributors - <http://sdrsharp.com> - Permission is hereby granted, free of charge, to any person Obtaining a copy of this software and associated documentation files, to deal in the software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and / or sell copies of the software, and to permit persons to -whom the Software is furnished to do so, subject to the Following conditions: The above copyright notice and this permission notice Shall be included in all copies or substantial portions of the Software.

In the last years the SDR applications have gone from amateur stage to a more mature phase and we have seen an unpleasant phenomenon, almost everyone (except us) has stopped publishing in Open Source and have started looking for ways to make money on it. This unfortunately declares the end of the pioneering and collaborative spirit that has enabled the rapid development of these techniques.

Without detracting from the great innovations introduced by each (eg from Youssef Touil who has really done a lot for the SDR) we must not forget, however, that none of this would be possible if before us many others had not published their work generously (from Fourier transforms, to digital filters, to the decimation principles and programming techniques in general). Without this background, published in good faith, none of us could have written these applications, including Youssef Touil.

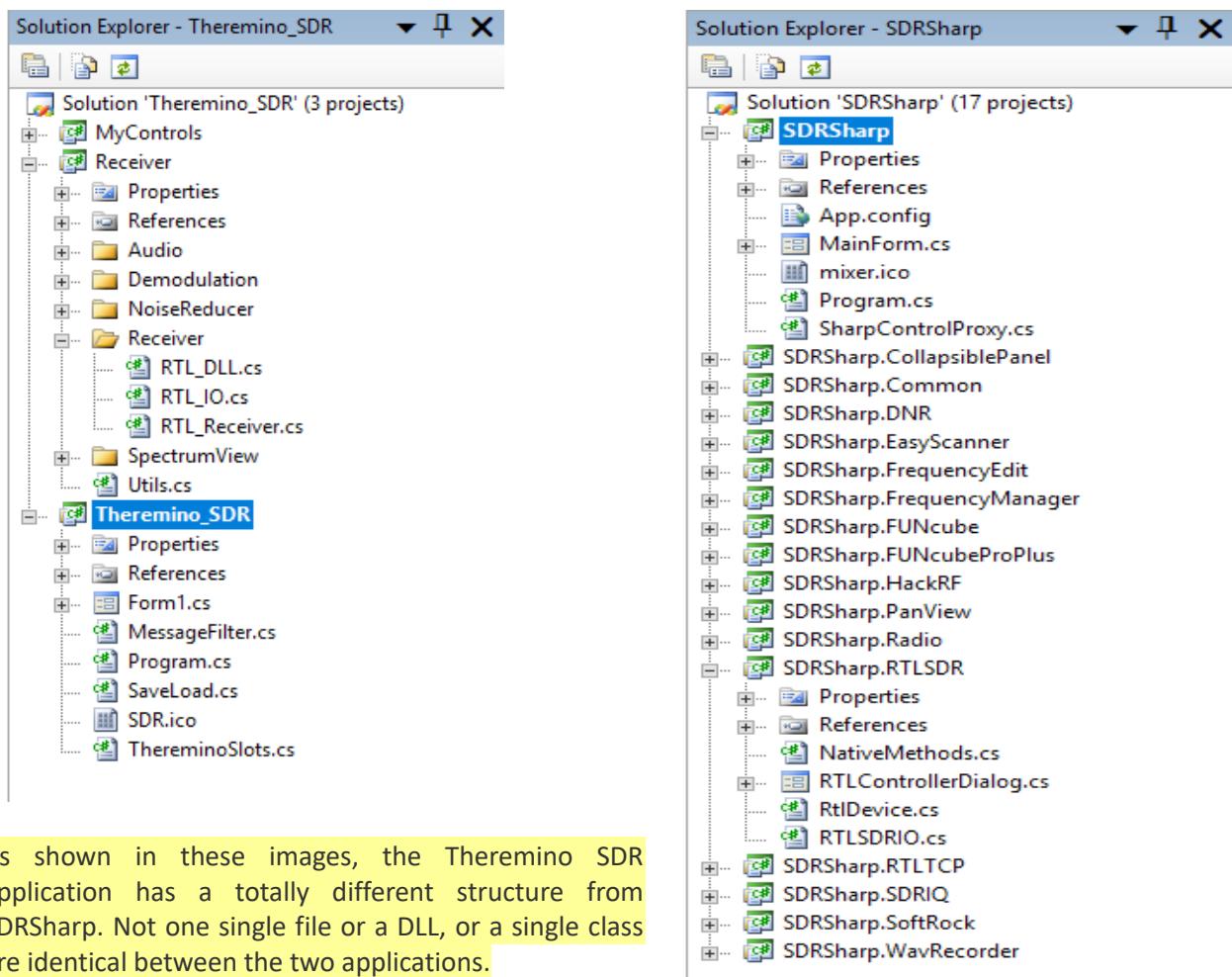
We therefore believe it is not right to betray the good faith of those who came before us, and of the GitHub contributors, and that there is fair appropriation of their work for profit. Therefore, even if all are abandoning the spirit of Open Source we will continue to publish. In this way everyone can benefit from innovations, including closed-source and commercial applications (that do not deserve it).

So, since all are closing their SDR codes, and considering that the compatibility features made slow and clumsy operation, we decided to totally eliminate compatibility with other applications, and the ability to use different from the cheap RTL-SDR receivers, that has more than enough performance for the teaching, DIY and automation. Today Theremino SDR remains similar in the fundamental parts, but is moving away more and more from other SDR applications.

# Differences and similarities with other applications

Theremino SDR is not a copy of other applications. It is a project written entirely by us with a totally different structure from any other SDR application. No project file and any DLLs are the same as those of other applications.

The more similar application is SDRSharp so we will do here a simple comparison.



As shown in these images, the Theremino SDR application has a totally different structure from SDRSharp. Not one single file or a DLL, or a single class are identical between the two applications.

For some parts of our application we used publicly available techniques, and for this we thank all those who before us have published their work. Then, in full respect of the Open Source spirit, we substantially improved these techniques and published all our contributions.

Our most significant contributions include the autoscaling techniques of spectrum analysis; the equalization of the gains in the various operating modes; the audio output limitation that eliminates distortion and unwanted noises; the input-output automation; a general improvement in ergonomics; and the development of specific controls for SDR applications: "Smeter", "TrackBar", "MyPanel" and "Numeric Display", more readable and easier to use. As well as a wholly new and immediate method, based on a convenient list, to store and restore frequencies and operating parameters.

We also carried out a complete revision of the fundamental SDR techniques, with hundreds of improvements and minor fixes. This is demonstrated by the significant reduction of CPU workload respect to other similar applications.

# What you will receive

## With the receiver only RTL and its small antenna, you receive:

- ◆ The commercial stations on the FM band from 88 MHz to 108 MHz. The reception quality is excellent, equal to the best FM receivers. Signals are strong, easy to receive, but technically of little interest.
- ◆ Service communications of the airports, helicopters and firefighters. Are usually short transmissions and difficult to get, it needs luck and patience.
- ◆ The encoded signals of open-gates, alarms and the like. In addition to receiving their commands, you can view with the spectrum analyzer, to put them up and repair them.
- ◆ The signals produced by meteorological measuring devices 330, 433 or 866 MHz. With the small antenna, attached to the receiver, these signals are received well, even through walls and from a great distance.
- ◆ If you connect a proper antenna you can also receive weather satellites of signals "NOAA", which decode in beautiful color weather images. See page 44.

With only the receiver RTL practically do not receive another, to receiver ranges of amateur radio it takes a UP-Converter. The application Theremino SDR works with all UP-Converter. but we We recommend Theremino upconverter, which is constructible with a few Euros and goes better than the more expensive up-converter business.

## With Theremino upconverter and Theremino ActiveAntenna you also receive:

- ◆ The stations at very low frequency of so-called standard time "Atomic", in LF and VLF bands. At these low frequencies the Theremino ActiveAntenna works wonders.
- ◆ The commercial stations in long waves.
- ◆ Beacons (Beacon) airports.
- ◆ The commercial stations on medium wave
- ◆ Various stations that give weather reports in ticker format.
- ◆ The commercial stations on shortwave
- ◆ The famous amateur bands (160, 80, 40, 20, 15 and 10 meters) with hundreds of transmissions receivable at all hours in the LSB, USB, RTTY and Morse.
- ◆ The bands "pirate" of 170, 88, 45 and 23 meters, frequented by amateurs without a license.
- ◆ The city band (11 meters). This band is almost abandoned and rarely hear anything.
- ◆ Sporadic maritime and military transmissions, medium and long waves in court.
- ◆ digital commercial stations, encoded in DRM (few and only at certain times of the day)
- ◆ Digital communications between amateur radio operators, coded freedv (few and random)

## Appendix 2 - The Theremino Up-Converter

Before designing the upconverter, we evaluated all possible alternatives, both commercial and to build with the "do it yourself":

**Entrance with SOUND CARD or ADC designed for sound cards** - This system is used by the receivers "FUNcube", "FUNcube Pro Plus" and "SoftRock" and would be a good idea if the bandwidth was sufficient. But unfortunately the audio band is only 20 kHz (compared to 2 MHz receiver RTL) for which the spectrum becomes so narrow (100 times closer) to make the system unusable as a spectrum analyzer (and uncomfortable as radio receiver).

**Modify the RTL receiver for the "Direct Sampling"** - This system is to blow up the tuner and connect the antenna directly to the chip 2832. Theoretically the idea is good, but in practice you have the following defects:

- 1) The input impedance is not exactly 50 ohms, and then the cable collects disorders.
- 2) No longer pass from the tuner and thus the sensitivity becomes poor.
- 3) To feel at least something, you must still add a circuit with some coils.
- 4) The additional circuit is more difficult to build our entire upconverter
- 5) The additional circuit is difficult to try and fit in the limited space available.
- 6) It must perform a difficult operation on the receiver, with small welds.
- 7) Very few would open the receiver just bought, threatening to destroy it. And many indeed destroy, using tools to weld inadequate.

**Use a HackRF** - This receiver in addition to cost so much, down only goes up to medium waves, completely precluding the possibility of receiving the LF and VLF, with time signals and other interesting "scientific signals".

**Use a commercial upconverter** - For example, the [NooElec HamItUp](#) (About 50 Euro), or the [Makis V1AFN](#) (About 70 euro). We rejected this solution because little by Maker, but also because, as they look so much "specifying", with a profusion of elliptic filters of yet another order, when put to the test are not very sensitive. And the lack of awareness means that you receive little or nothing, even with the best antenna.

For those wishing to try the SV1AFN it is definitely better, has at least one pre-amplifier to compensate the losses of the mixer diode. But does not an adjustable attenuator, so if you put the pre-amplifier weak signals are covered by intermodulation, and if you disappear off the weak signals.

# The circuit diagram of the Up-Converter

The pattern of the up-converter, the advice for the construction and the latest version of the project are here:

<http://www.theremino.com/hardware/adapters#upconverter>

We experienced long, to achieve a simple but effective circuit. So nothing elliptical filters, with dozens of capacitors, which give an appearance so "professional" to projects similar to this. They must have a "professional and accurate look," because they have to sell them. We however only importing the proper functioning and simplicity.

Although the look is simple, the points that really matter are cured, compared to other projects. It is the constant input impedance, the perfect balance of the mixer and continuously adjustable attenuation. The PCB is constructible on Stripboard and you just use common components. Some horrified seeing the components that we choose to use. There are 4002 diodes in the signal path, nothing elaborate filters and nothing mixer diode ... sacrilege !!!

We chose to use the NE602 (or NE612, SA602 and SA612 that are equivalent), instead of the mixer diode used by other UP-Converters. The mixer diode lose about seven decibels and produce signals below the noise floor of the ADC. Instead our converter earn more than twenty decibels, for which the sensitivity to weak signals is better.

The authors propose that the mixer diode forget to consider that the RTL receiver has a low tolerance for strong signals and little dynamic (low ratio between the maximum signal and the minimum), because of its 8-bit ADC of the poor. In these difficult circumstances there is no better than an active mixer. A NE602 requires to be adapted more closely to a mixer diode. But our project reduces the possibility of overload, both for the mixer that for the RTL receiver, and it can eliminate most of the filters.

Some circuits that use the NE602 (eg the famous ELECRAFT) avoid overloading the mixer with a 14 dB attenuator. Attenuators snap of this kind are copied, verbatim, from school books, and explain how to maintain a constant impedance. But in our circuit, we regulate the continuously gain and guarantee the constant impedance with a transistor. This solution allows to always be at the limit of saturation and to always obtain the highest possible sensitivity.

One key point that makes this circuit different from all others is that the shielded cable from the antenna is terminated on a pure resistor (50 or 75 ohms depending on the cable). In this way it completely eliminates the tendency of the cable to collect noise from the electrical system. A transistor decouples the input filters from the cable and allows to have a purely resistive and constant input impedance, across the range of receivable frequencies.

This termination scheme provides the power to the active antenna, through the same termination resistor, simplifying the power supply circuit, eliminating the current injection of the coil (that for low frequencies becomes problematic), and then eliminating the noise coming from the AC .

The power injected on the "cold" of the resistor does not contribute to the noise, however other schemes, which do not use this system and having constant problems with noise, so much so that some even come to recommend to feed the antenna with a stack.

# Comparison between NE602 and mixer diodes

Many authors advise against the NE602 for its poor tolerance to strong signals. Some even go so far as to write that a receiver, with this integrated, automatically becomes a toy. See for example this: [http://traktoria.org/files/radio/rf\\_mixer/Why NOT to use the NE602.pdf](http://traktoria.org/files/radio/rf_mixer/Why_NOT_to_use_the_NE602.pdf)

Documents like this made us lose months of time. We have tried every type of mixer diodes, but on time all the evidence ended with the worst results of the NE602. We tried considered very good mixer diodes (ADE-1), mixer self-built with 1N4148 diodes, with shottky diodes and germanium diodes, following [As written here](#), is [these instructions](#) is [also these](#).

But all the up-converter for RTL2832, with mixer diode, were worse than the benchmark, with NE602. So in the end we got to deal seriously and we understand why.

## The calculations confirm that the test

### intermodulation

The maximum input level (1 dB compression point) of the NE602 is -13 dBm. Instead a good mixer diodes (The ADE 1) up to +3 dBm.

At first glance the mixer diode, which supports signals up to + 3dB, is better. But we forget to consider that the NE 602 amplifies the signal of 17 dB, while the mixer diode loses 7 dB. Whereby a diode mixer is 24 dB less sensitive and weak signals you will not receive.

To achieve the same sensitivity of the NE602 is necessary to precede the mixer diode amplifier 17 + 7 dB = 24 dB. But amplifying of 24 dB, the mixer diode begins to saturate 24 dB lower. Ie drops to +3 dB -21 dB, that is a significantly lower level to that of the NE602, almost three times worse. These levels are shown in the table on next page.

If it is then considered that the pre-amplifier intermodulation adds to the system, the end result is that RTL2832 a receiver with up-converter diode is considerably worse than one with NE 602. And that's exactly what we have encountered in our tests, in the period from summer until December of 2015.

### local oscillator attenuation

Since the RTL receiver has little dynamic and easily saturated, it is important to minimize the amplitude of the 125 MHz local oscillator that can pass through the mixer.

With the mixer ADE1 the attenuation at 125 MHz is:

- 58 dB (if you enter from the pin 2 and exits from 6)
- 43 dB (if you enter from the pin 6 and exits from 2)

So in the two cases, starting from the local oscillator to + 7 dBm, you are obtained:

- 51dBm, approximately 630 uVeff
- 36dBm, approximately 3.5 mVeff

The datasheet of the NE602 does not specify local oscillator attenuation, but our tests show that the values around -40 dBm (output signal on pins 4 and 5). Values are similar to those of the ADE1, but given that the useful signal in the NE602 output is 24dB higher than that of the ADE-1, It confirms the great superiority of the NE602 compared to the ADE-1 (when used in an up-converter for the RTL2832).

# Conversion tables from dBm to voltage

## Table of dBm (about 50 ohms) and of the voltage values

+7 dBm = 500 mVeff - ADE1 local oscillator (1.4 Vpp)  
+3 dBm = 311 mVeff - ADE1 max signal before intermodulation  
0 dBm = 220 mVeff - NE602 local oscillator (> = 200mVpp)  
**-13 dBm = 50 mVeff S9 + 60 - NE602 max signal before intermodulation**  
-20 dBm = 22 mVeff  
**-21 dBm = 20 mVeff - ADE1 max signal before intermodulation (with 24dB preamp.)**  
-33 dBm = 5 mVeff S9 + 40 - NE602 local oscillator output from pins 4-5  
-36 dBm = 3.5 mVeff - ADE1 local oscillator output from pin 2  
-40 dBm = 2.2 mVeff - NE602 local oscillator after the output transformer  
-51 dBm = 630 uVeff - ADE1 local oscillator output from pin 6  
-53 dBm = 500 uVeff S9 + 20  
-60 dBm = 220 uVeff  
-73 dBm = 50 uVeff S9  
-80 dBm = 22 uVeff  
-84 dBm = 14 uVeff S7  
-93 dBm = 5 uVeff  
**-96 dBm = 3.50 uVeff S5 - ADE1 sensitivity (Without 24dB preamplifier)**  
-100 dBm = 2.20 uVeff  
-108 dBm = 0.88 uVeff S3  
-114 dBm = 12:44 uVeff  
**-120 dBm = 00:22 uVeff S1 - NE602 sensitivity (Or ADE-1 with 24dB preamplifier)**

The sensitivity indicated, refers to a ratio of 10 dB signal-to-noise. To calculate the stresses of impedances other than 50 ohms, use the [online converter of this page](#)

From this table we see that the range of the NE602 ranges from -13 to -120 dB, so we have over 100 dB of room between the maximum and the noise signal. This range is much greater than that of the RTL receiver that, because of its 8-bit ADC, has just 50 dB dynamic range.

So with the NE602 It remains an adjusting margin of more than 50 dB and is sufficient to adjust the sensitivity of the antenna (with a potentiometer) and the "Tuner gain" (in the application SDR) so as to work the converter and the receiver with the most appropriate voltage levels .

By adjusting the antenna gain just below the limit of saturation and then also the "Tuner gain" to the limit of saturation, you get the highest possible sensitivity and the maximum signal to noise ratio for weak signals.

These adjustments will be different from day to night and also depend on the propagation conditions, which can significantly change, even in less than one hour.

Usually the antenna gain is little more than half and holds the TunerGain around 10 dB, or less. These values will be decreased on the low frequencies (below 10 MHz), when there are strong disorders and strong atmospheric noise. Instead one could increase them, even to the maximum, in periods of silence, and in the higher frequency bands (10 to 50 MHz).

To obtain the maximum reception quality is part with the low sensitivity: antenna gain less than half and TunerGain to zero. He will raise the antenna gain until you see appear obvious signs of intermodulation in the spectrum (lines that suddenly sprout from the bottom noise) and takes you back a bit'. Then he gets the TunerGain, up to see tick lines intermodulation and going back until they disappear. In these conditions, you obtain a sensitivity comparable to that of the best commercial receivers.

## Appendix 3 - The antennas

The antenna supplied as receiver accessory RTL2832U, It has a good efficiency from 200 MHz up. So it is great to receive signals at 433 MHz and 866 MHz, the small weather stations and the transmitters are encoded with Motorola chip, Holtek and the like. And you can also use the FM band (88 to 108 MHz), since in this band the signals are strong.



To receive signals from 50 Mhz to 200 Mhz (Services, police, health, fire, airports and amateurs) who are pretty weak, you need an efficient external antenna.

for short medium and long waves (10 kHz to 50 MHz) you have to go from Theremino upconverter and a must use for strength external antenna, otherwise the only stations receivable will be disturbances, irradiated by the electrical system of the house.

In all cases, the external antenna must be connected with a shielded cable 50 ohm (or 75 ohms with a small change to Theremino upconverter). The shielded cable must be exactly the same dell'UpConverter input impedance. This is very important to avoid that the cable shield behaves as an antenna and receives interference from the wires of the electrical installation.

The shielded cable has to start from the receiver and go to the outside, At least out of a window, but preferably up to a few meters from the outer walls of the house. Ideal get up a tree or a terrace which has a long metal railings, or better still to the roof. Careful to stay away from electrical wires and poles used for electrical connections.

At the end of the shielded cable connecting the antenna, while the ground can be connected to the shielding braid, at any point along the cable.

**The antenna** - You get a good antenna, with a simple wire electrical system, from 2 to 4 mm square section. Peels the ends you connect to the central shielded cable, then you pull the thread and binds to something high, or it slants down from the balcony or window. The length ranges from a minimum of a few meters to tens of meters and it is not necessary that the wire is straight, you can also make the "V". A long thread favors the long waves, but worsens the short waves because more noise collects. With a wire 10 meters long, you receive well the band of 40 meters, which is the most interesting for radio amateurs.

**For best reception**, And for cases where you do not have much space, the Theremino ActiveAntenna is very indicated. See the following page.

**The earth** - It should be connected to the metal braid at the end, or at any point along the cable screen. As the ground you can use any very large metallic object, such as the metal railing that surrounds a terrace, and even better if the balcony is on the roof. Or you can use the metal gutters, possibly joining them one to the other with pieces of wire for electrical system. It is punctured with the tip of three and using wires terminated with grommets and self-tapping screws. Caution Always stay away from wires and poles of the electrical systems. A good ground will increase a bit 'the signal, but most fall very much noise.

# Theremino Active Antenna

**How can a small antenna work better than large antennas, traditionally used by radio amateurs?**

The purpose of an antenna is to collect the maximum signal and the minimum possible noise from the electromagnetic waves. Which, as the name implies, they are composed of an electric field and a magnetic field.



The noise is generated in households and generally in residential areas, from electrical appliances. The noise is both electric and magnetic, but the magnetic noise is lower than electric. So it would seem more logical to use antennas sensitive to magnetic field variations (for example, a loop antenna or the classical antennas tuned rows). However, the magnetic noise easily goes through walls while the electrical noise is attenuated much from them.

Therefore a sensitive antenna to variations of the electric field, placed outside, far enough away from the walls of the house, in the garden or on a tall pole on the roof, receives less interference and noise of a classic dish.

## Tips for active antenna

The external screen, the long wire that goes to the antenna, must be connected to ground, heating pipes or to metal water pipes. Alternatively you could connect it to a large metal object outside the house, as the metal railing of a balcony. One must use the electric circuit ground, because it contains a lot of noise in radio frequency-induced appliances.



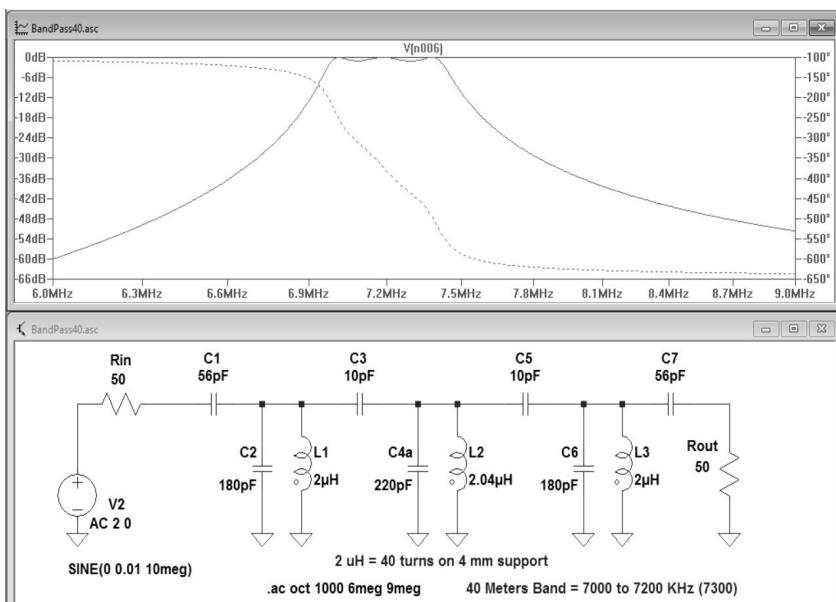
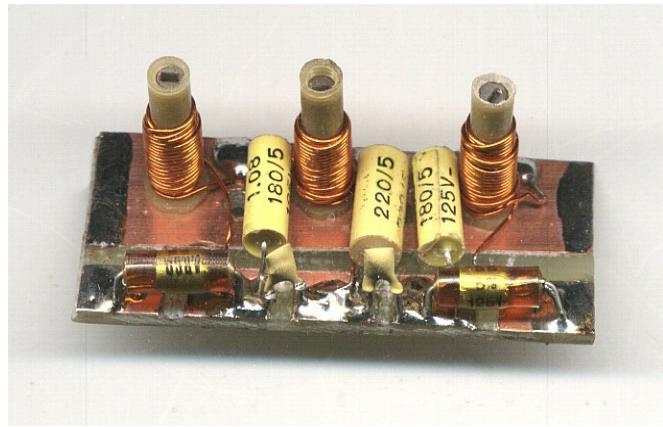
The receiving element shape is not important. Up to that the dimensions are negligible compared to the wavelength, an active antenna is omnidirectional and can always be formed by a stylus, a wire, a tube or a flat surface, however oriented.

The Theremino ActiveAntenna project, with PCB, simulations and images on this page are:  
<http://www.theremino.com/hardware/adapters#activeantenna>

# The pre-selector

A selector eliminate out of band signals. So theoretically should eliminate inter-modulation and improve reception of weak signals. but abbiamo did a lot of tests and we have verified that you do not get significant improvements.

If the receiving chain is well designed, the mixer is doubly balanced, and precisely tune the amplification levels, before and after the mixer, then the inter-modulation is not a problem and receiving weak signals with highest sensitivity possible.



In these conditions, add or remove the selector does not increase, we tested at length on every kind of signal, both in the days of weak propagation (when you do not feel that a few signals), both during the "contest", in moments of maximum number of people, and even at night, when commercial broadcasters are stronger.

We kept always ready switch and we did tests on the weakest signals and the best possible pre-selector, the narrow band that you see on this page.

All signals, even weak, could be received just as well with the shift rail excluded. The only improvement was given by the selector to be able to raise all gain controls to maximum, without excessive inter-modulations caused by commercial stations. But this is not a real improvement because, to get the best reception, the gain controls should always be set at the right point. And when they are properly adjusted, put on or take off the selector does not change anything.

The best pre-selectors have the disadvantage of being fixed on a band, while those regulated are not sufficiently selective on certain frequency bands and are too much on the other. And they are all difficult to build and to be calibrated. In the end we removed the switch and all the selectors test by the receiver, and put everything preserved in a box. Anyone wishing to try for yourself, find the best of our projects in this file: [Theremino\\_SDR\\_Preselectors\\_V1.zip](#)

Warning: if you use the active antenna must "jump" the shift rail with two impedances (to bring the power to the antenna) and two capacitors to ground (to stop the passage of the radio frequency), as shown in simulations "PowerSupplyAdapter.asc" and "Preselector3.asc"

# Protection circuits for lightning

The ActiveAntenna, the upconverter module and the receiver RTL2832, even withstand the shocks of the nearest lightning and powerful. If, however, that a lightning directly hit the antenna, no protection would be sufficient, the entire antenna will merge into a lump of metal and plastic smoldering. But do not worry, it does not happen ever, or at least not as often being affected personally by lightning.



Fortunately, the "Active Antenna" is completely covered in insulating plastic, so there is a good path for the electrical current and thus not "attract" lightning. That said, the same should take every precaution possible, if only to sleep soundly even during storms, and avoid getting out of bed to get away from the receiver antenna.

A truly effective barrier between the antenna and the receivers (and the PC) is to interrupt the path of the lightning along the shielded cable. In practice peels the shielded cable at a suitable point and connect the shielding braid to a good ground. For the connection using a single cable from electrical plant, of large diameter, for example, four square millimeters and not longer than a few meters.

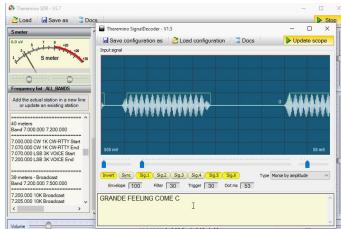
The best are the ground water or the heating pipes, but they must be metal to the aqueduct. As a second choice could be used metal poles or underground grids deep, damp earth, and perhaps with the help of salt to increase conductivity. You should never use the electric circuit ground, because it would send noise at the receiver and significantly worsen the reception of weak signals.

Additional security, are two 1N4002 diodes in anti-parallel, welded between the screen and the core wire of the shielded cable. The most comfortable spot where weld is the connector that goes to the receiver, or the BNC connector on the receiver itself. These diodes do not degrade the shortwave reception, but eliminate any extra tension. In the worst cases they are shorted and protect everything else.

# Appendix 4 - Decode signals

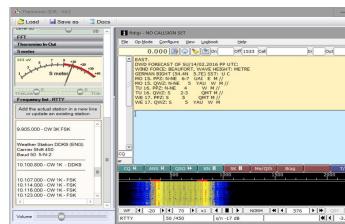
Theremino SDR receives signals with basic types: FM, AM, SSB and CW. After demodulation almost all the signals are clear, listenable and understandable. But there are some signals, which are to be sent to specialized programs, for further decoding.

## encoded signals - Remote controls, transmitters Weather and Morse



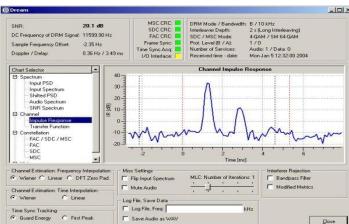
To receive these signals using the application Theremino Signal Decoder.  
See pages 38, 39 and 40.

## RTTY signals - Weather Stations (and other services based on teletype)



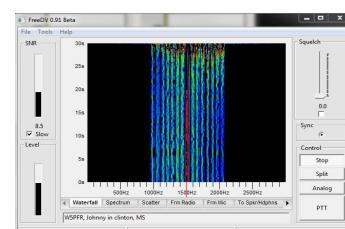
These signals (and many other similar) will decode the Fldigi application.  
See page 41.

## DRM signals - commercial stations that broadcast music and news.



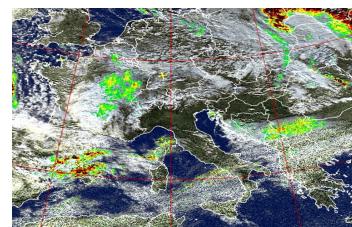
To listen to these stations using the DREAM application.  
See page 42.

## Freedv signals - Conversations between amateur radio with digital encoding.



To listen to them using the freedv application.  
See page 43.

## NOAA signals - Maps of Meteorological Satellites.



The maps of weather satellites is decoded with WXtoImg application.  
See page 44.

# The VB-Cable



The VB-Cable allows you to transfer audio signals directly from one application to another, without letting them pass by the sound card.

## Advantages of VbCable than transfers with the basic Windows mixer

- You can transfer audio signals without hearing the speakers.
- The bandwidth is limited to 20 kHz, as is the case with some sound card.
- The transfer takes place digitally, with maximum quality and efficiency.
- The sounds generated by the operating system does not disturb the transferred signal.

## In such cases you should use the VbCable

For some signals, such as Morse code, when hear the audio received is not a problem, the VbCable is not necessary and simply select the line "Stereo Mix."

If there is no "Stereo Mix" go to:

Control panel

Audio

registration

Press the right mouse button

Enable "Show Disabled Devices" and "Show disconnected devices"

Enable the "Stereo Mix" (unfortunately not all sound cards have)

But there are hard signals, which require more bandwidth or are decoded into an audio and thus disturb their own decoding (eg DRM and FREEFDV). In these cases it must necessarily pass from VbCable.

## Download and install the VbCable

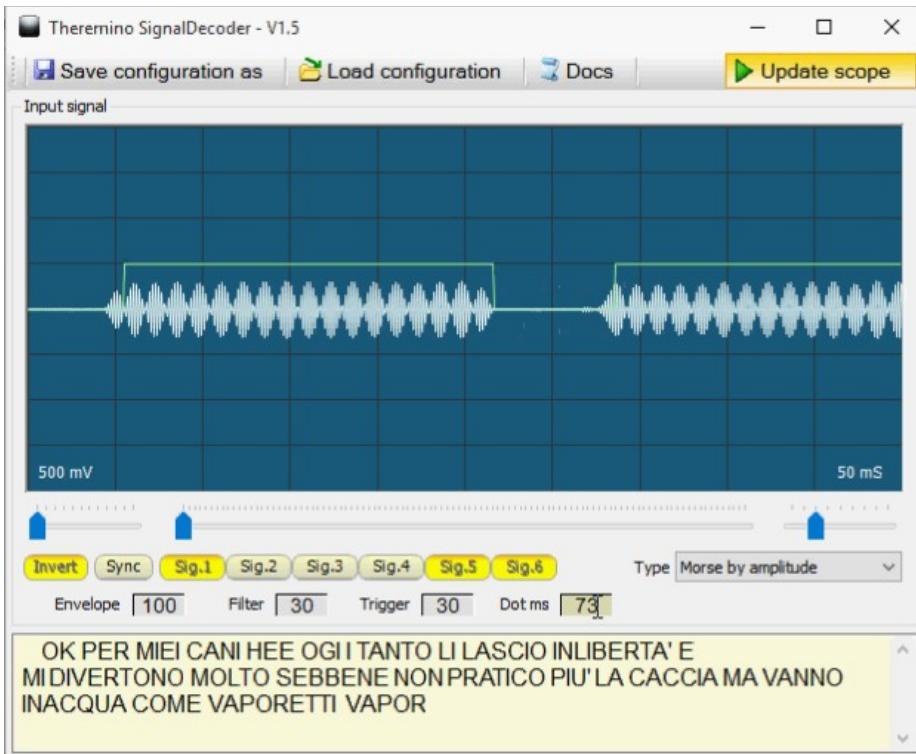
The VbCable is not open source, but at least it Donationware, and it is easier to use, and easy to install, similar to paying drivers.

Follow this link to download it:

<http://www.vb-audio.com/Cable/index.htm#DownloadCable>

- Then decompress the files in any folder and launches the "VBCABLE\_Setup.exe"
- In the event that the operating system is 64-bit, choose the file "VBCABLE\_Setup\_x64.exe"
- In all cases you must use the right-mouse and choose "Run as administrator"

# Decode Morse code



To decode Morse you can use various applications such Fldigi. But they are all quite complex to adjust and not better decode our simple "Theremino SignalDecoder"

- The "SignalDecoder" you download from here:  
<http://www.theremino.com/downloads/automation#signaldecoder>
- the "Load configuration" and choose "Configuration\_Morse.txt" menu opens.
- Adjusting the parameters Envelope, Filter and Trigger as in the image above.
- Adjusts "Dot ms" depending on the transmission rate. Usually around 50 mS, and rarely up to 30 mS for lenses operators, and up to 80 mS, for fast operators.
- The milliseconds to set can be measured in the signal window. You have to watch the width of the narrow pulse (points). You can help yourself by disabling the "Update button scope" ( "Run in the latest versions") to stop updating when appropriate.
- The latest versions of the Signal Decoder have two new controls, to choose the device from which the audio signal (usually "Stereo Mix") and to adjust the properties of the audio input device ("Audio inputs" button).

**Video with examples of decoding Morse Code:**

<https://youtu.be/eaK9QHX0VVs>

<https://youtu.be/xwpt4BjZKYo>

<https://youtu.be/D6nTDDXkR2U>

# Decode the signals of remote controls

This category includes various types of encoded signals, for the car locks, openers-gates, the burglar alarm, the temperature and humidity sensors, and so on ...

## remote controls

With comfortable transmitters shaped key ring, you can controlled by radio, the Theremino system applications. A single SDR receiver can receive multiple remote controls with different codes together. The commands are interpreted by Theremino SignalDecoder and, if recognized as valid, are decoded and their codes written in the slot. IS in Theremino system once you get to the slot you can do everything.



The signals from remote controls currently implemented are:

- 5026/5027/5028 (Motorola)
- EV1527 (Silvan Chip Electronics)
- HT12E (HOLTEK)
- MM53200 (National)
- UM3750 (UMC)

By varying the parameters you can decode other similar models, or adjusted with higher or lower bit rate.

The signals of the remote controls do not have a precise and stable frequency. It is said to be at 433 MHz (or 866 MHz), but can also be quite far away from these frequencies. For example, 432.7 MHz or 433.6 MHz. And even after having tuned can change frequency, according to changes in temperature and battery voltage. So, to make sure you receive them, you may want to use "Tune to max ", which is in the "Demodulation" panel and explained on page 9.

## weather sensors



Almost all homes have sensors for the temperature and the humidity. They are built from "Oregon Scientific", "La Crosse", "Auriol" and the like. And there are also models to be placed on the outside, for the wind and rain.

It would be interesting to read and send the values measured on the slot, available to all other thereminiche applications.

The application Theremino SignalDecoder already contains everything needed to decode them, but they are long codes and complex and will require a bit 'of work ... so currently the weather of the sensor signals are not yet implemented.

# Broadcast on the "free use" bands

You can perform transmission experiments, with transmitters SRD (Short Range Devices) and also transmit data, in the context of small systems at short distances.

The following bands are granted for free use by the Radio Regulations of the ITU (International Telecommunications Union), by reason of the provisions in the 5116 notes, 5.138 and 5.150.

Before using these frequencies to transmit, it is good to read up on the latest regulations of your country.

Frequency range	Remarks
9.0 to 148.5 kHz	Inductive SRD applications
3155 to 3400 kHz	ISM band (RR No. 5.116) / Inductive SRD applications
6765 to 6795 kHz	ISM band (RR No. 5.138) / Inductive SRD applications
13,553 to 13,567 MHz	ISM band (RR No. 5.150) / Inductive SRD applications
26,957 to 27,283 MHz	ISM band (RR No. 5.150) / Inductive SRD applications
40,660 to 40,700 MHz	ISM band (RR No. 5.150)
2400 to 2500 MHz	ISM band (RR No. 5.150) (the upper limit is 2483.5 MHz in some countries)
5725 to 5875 MHz	ISM band (RR No. 5.150)
24.00 - 24.25 GHz	ISM band (RR No. 5.150)
61.00 - 61.50 GHz	ISM band (RR No. 5.138)
122-123 GHz	ISM band (RR No. 5.138)
244-246 GHz	ISM band (RR No. 5.138)

Merely transmit ON-OFF signals very slow and tightening the bandwidth at some Hertz, could be transmitted over very low frequencies, at a great distance, with negligible power.

very low frequencies (in the band from 9 kHz to 148) may be generated by FastPwm of a Theremino Master, perhaps with the addition of an amplifier transistor and a coil wound on ferrite as a transmitting antenna. Then you could control the duty cycle, setting it to zero and 50%, to turn off and turn on the carrier.

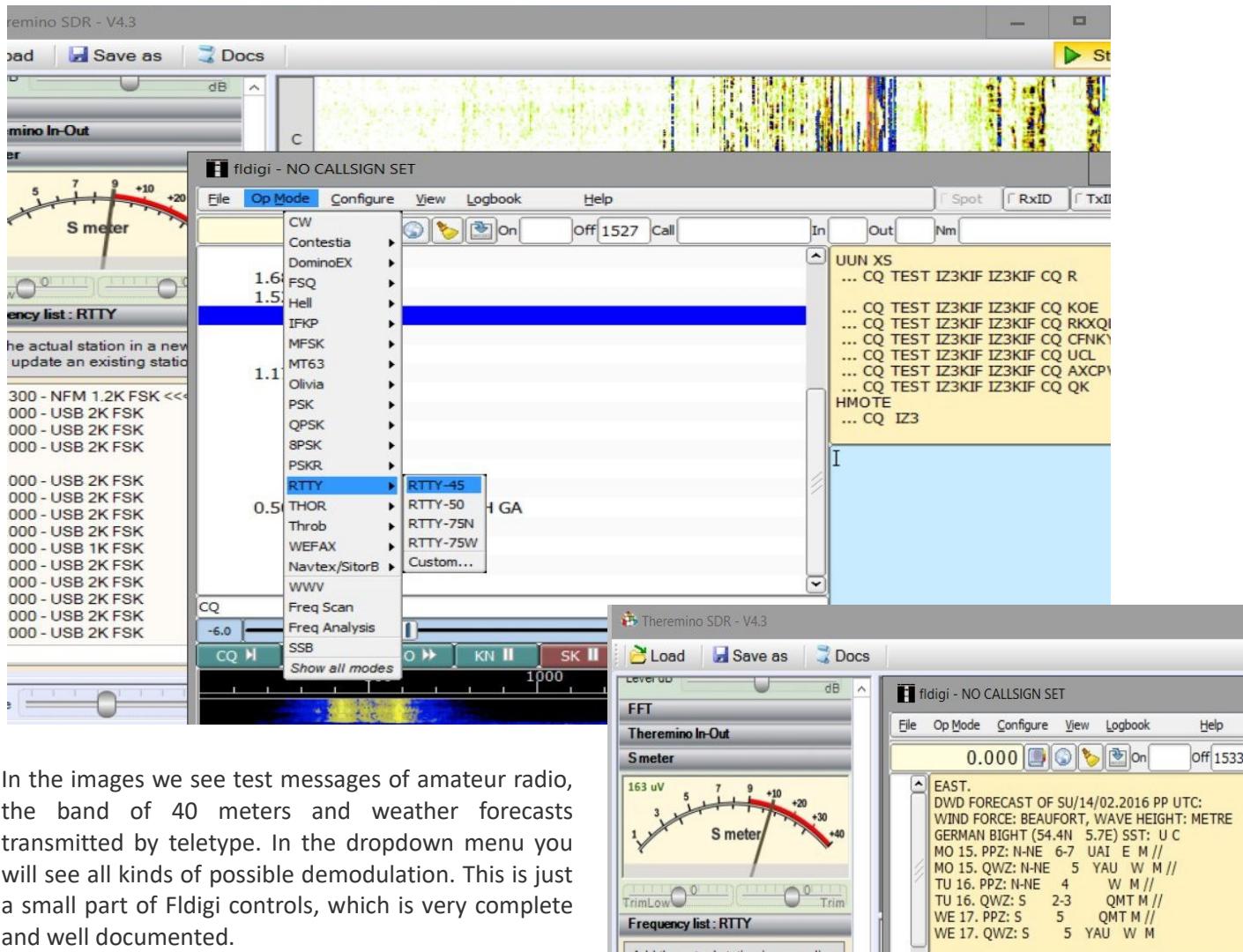
Or you could use small quartz based oscillators or free, in 5 more free bands up to 50 MHz and drive them with a DigOut output. On the net you can find patterns of small oscillators like this.

With unstable oscillators (Eg those of the car remotes) or when using a bandwidth, you can use the function "Tune to max" to chase the signals.

Of course they will receive the signals with Theremino SDR and will be decoded using Theremino Signal Decoder. Finally, the decoded value will be available in one slot, in order to be used by other applications of Theremino system.

# Decode RTTY (and other) signals

By sending the audio signal to Fldigi application, you can explore and decode signals of any kind. By teletype (RTTY) to Morse code, the weather images, the FAX modems, and of all kinds. Course Fldigi is OpenSource and then you can use it with confidence. We know him well, and does not hide unwanted code.



In the images we see test messages of amateur radio, the band of 40 meters and weather forecasts transmitted by teletype. In the dropdown menu you will see all kinds of possible demodulation. This is just a small part of Fldigi controls, which is very complete and well documented.

This video shows the reception and decoding of the weather bulletin of the German broadcaster DDK9 you receive a 10.1 MHz: [https://www.youtube.com/watch?v=a328\\_j\\_SM2M](https://www.youtube.com/watch?v=a328_j_SM2M)

The files of Fldigi should be here: <http://www.w1hkj.com/Fldigi.html>

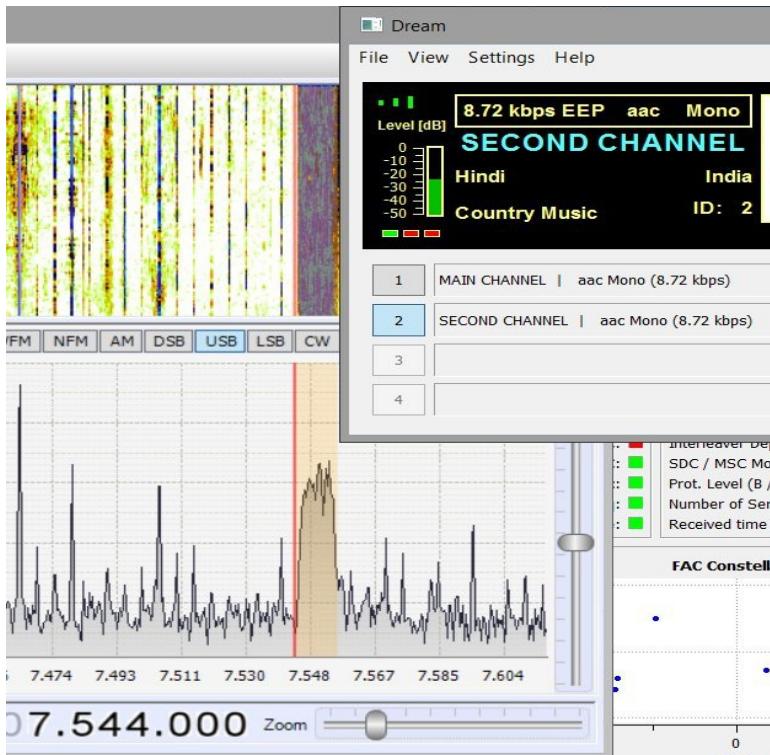
But since they had problems on the site, the files have been moved to SourceForge:  
<https://sourceforge.net/projects/fldigi/files>

Unfortunately, the files have the ".exe" to be installed, which in many (and to us) like little. So we rebuilt the necessary files, we checked them well and we have prepared comfortable ZIP, to unpack and use wherever you want, without installation.

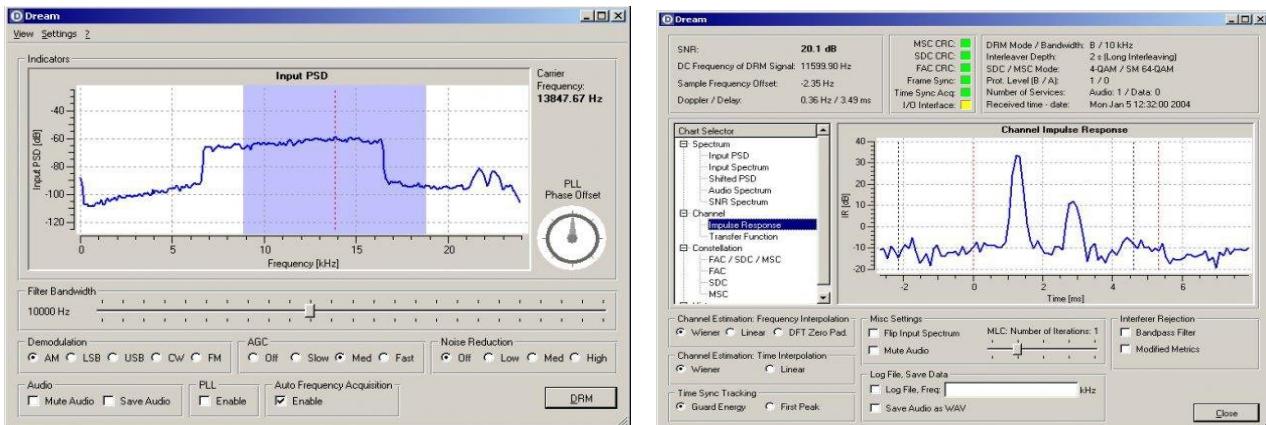
<http://www.theremino.com/wp-content/uploads/files/FLDIGI-3.23.07.zip>

[http://www.theremino.com/wp-content/uploads/files/FLDIGI-3.23\\_Users\\_Manual.pdf](http://www.theremino.com/wp-content/uploads/files/FLDIGI-3.23_Users_Manual.pdf)

# Receiving DRM encoded stations



The DREAM application is well maintained and contains control functions and sophisticated measurement, as seen in the following images:



Dream you download from here: <https://sourceforge.net/projects/drm>

And its documentation is here: [http://drm.sourceforge.net/wiki/index.php/Main\\_Page](http://drm.sourceforge.net/wiki/index.php/Main_Page)

## Tips to receive DRM transmissions Theremino SDR

- Use the command "Load" and load the "Test\_Digital\_DRM" file.
- Try all of the lines of "Frequency list" and locate a DRM signal.
- The DRM signals are recognizable, for the rectangular shape, with about 10 KHz wide.
- Go to the Audio pane and select the signal output on VbCable.
- Open DREAM and select "Settings", "Sound card", "Input Signal", "Device" and finally "VbCable"

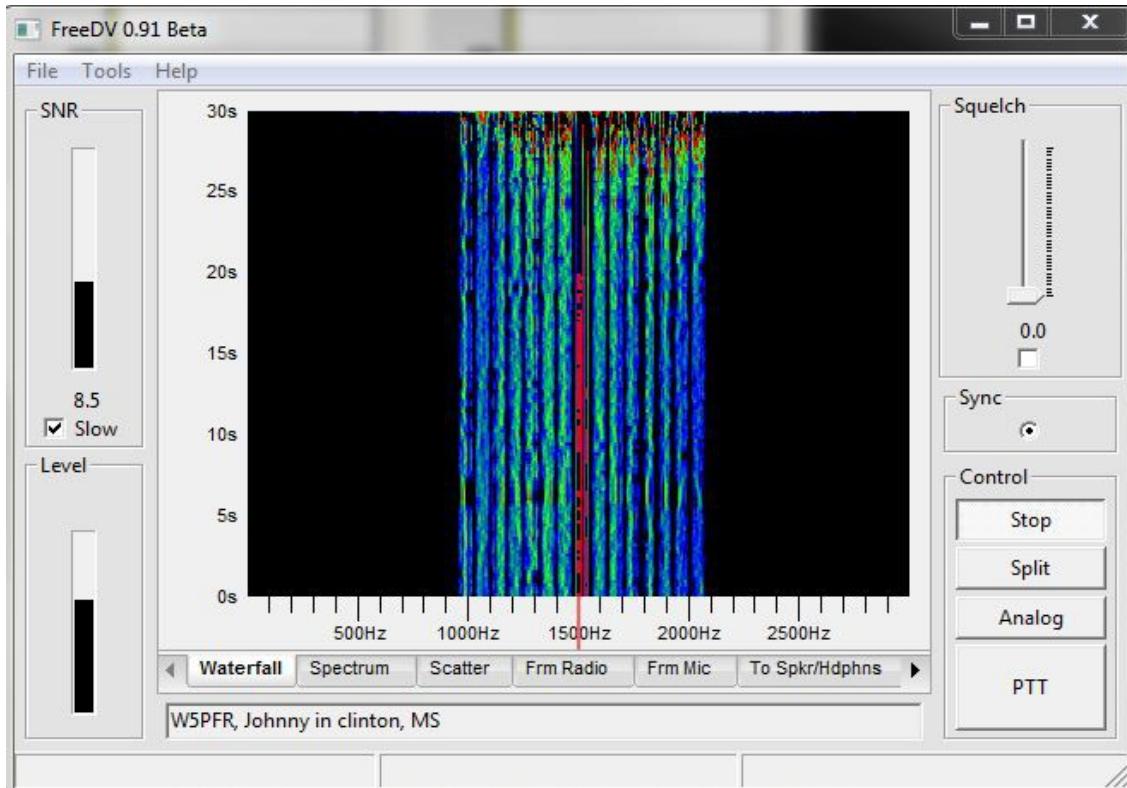
Some commercial broadcasters shortwave broadcasting in digital, DRM encoding (Digital Radio Mondiale).

To receive these transmissions using the application "DREAM", even it Freeware and Open Source.

Unfortunately stations with DRM encryption are few. If they receive three or four and not all day. And, even worse, all transmit in mono and only programs for the Orientals, at least those receivable from Europe.

In the US and Canada they are more numerous and transmit the most interesting programs.

# Receiving conversations with freedv coding



Some conversations between radio amateurs are encoded with freedv, also freeware and Open Source.

With freedv you get a perfect connection, without the noise and hiss, even with weak and noisy signals. However, below a certain level that, as disturbed, it would still be comprehensible, the freedv stops working completely.

Not many radio amateurs who use it, so it takes luck and patience to get them. And you must also be skilled and fast because after identifying a signal, you must set Theremino SDR to send the audio signal to the VbCable, freedv launch the application, set it and start decoding. Usually after doing all these steps, you find that the signal is diminished or that the connection is over, or that the reception quality is not sufficient for decoding.

This is the official site where you can download freedv

<http://freedv.org/tiki-index.php>

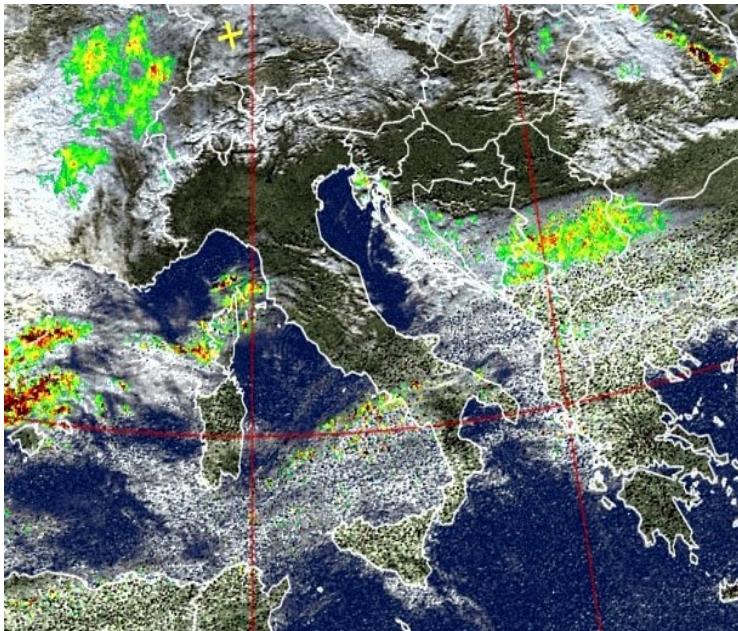
On YouTube there are guides freedv. Some are quite complex because it also explains how to connect the microphone to transmit. But we are interested in only the receive part:

<https://www.youtube.com/watch?v=ovAJBkOWKZ4>

<https://www.youtube.com/watch?v=iRoETPOjq7Y>

<https://www.youtube.com/watch?v=zijJ556cs08>

# Decode Meteorological Satellites



Disturbances on Italy in the south, on February 11 of 2016, seen from NOAA19 satellite.

## Antenna

To receive the best satellite antenna is the QFH "antenna to Propeller Quadrifilar". It should not even direzionarla on satellite, just fix it vertically and well-open position. On the Internet there are many instructions to build it, the best that we have identified in these files:

[Building QFH Antenna ENG](#)

[Building QFH Antenna ITA](#)

## How to receive Weather

### satellites

- Install the excellent free WxtoImg application, by choosing and starting the download for Windows, from this page: <http://www.wxtoimg.com/downloads>
- WxtoImg launch and set your latitude and longitude, by opening the "Options" menu and then "Ground Station Location".
- Open the "File" menu and choose "Satellite Pass List"
- Locate the next useful step in the column "Local Time"
- Note the "NOAA 15/17/18/19" satellite and frequency.
- Set the frequency in Theremino SDR (in the Frequency list already contains the four NOAA satellites with their frequencies)
- Remember to disable the "Converter Shift" in the Receiver panel and switch the receiver to skip the upconverter, if any.
- Make sure that the recording and playback devices in the Windows menus are in place.
- Finally, open the "File" menu of WxtoImg and choose "Record" or "Decode"

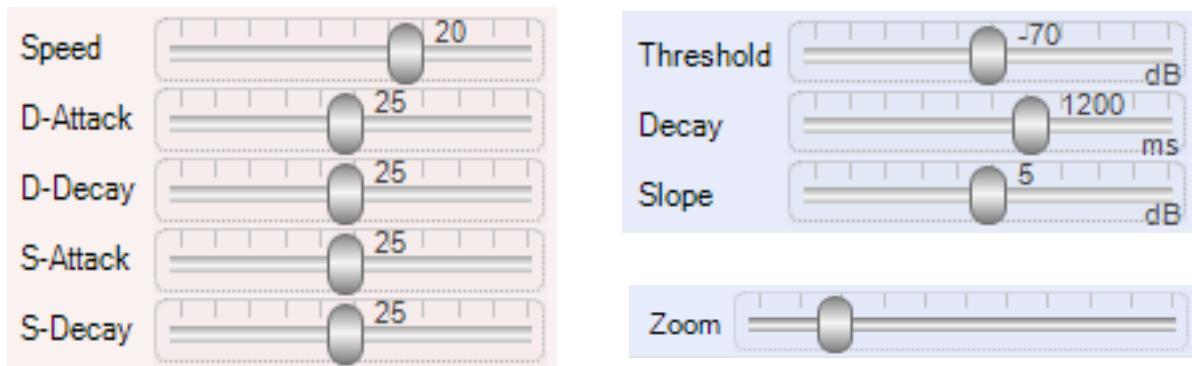
### Theremino SDR setting for receiving satellites

Set the receive mode of WFM and the bandwidth of 34 kHz filter. If there are no interfering signals neighbors, it is possible to increase the bandwidth of 40 kHz filter so as to make less critical the tuning.

Sound transfer from Theremino SDR towards the WxtoImg application, can be through the "Stereo Mix", but it is better to use the VB-Cable. The sampling frequency must be set to at least 48000 samples per second. To set it, click on the right speaker (bottom right) and open the recording devices, go to the properties of the recording device and under the "Advanced" tab, set the sample rate of 48000 Hz. Do the same in the device which is used in the Playback tab.

# Appendix 5 - Sliders

The sliders of this application have special properties that make them better than the regular Windows cursors and DotNet. Here we will explain how to use them and make a list of properties that distinguish them from other similar components.



These sliders can be adjusted by the mouse and with the mouse wheel. But you can also use Up Arrow of the keyboard. Or PageUp is PageDown for more rapid movements. Clicking the right mouse button It sets the "Default value".

## List of additional properties.

Are the properties that distinguish this control from the normal Microsoft controls. This part can be useful to programmers, that copy the class "MyTrackBar", in their applications. Soon we will publish also on Theremino site, both in CSharp version VBNET, to facilitate the development of new applications.

**TickCount** - You set directly number of notches. Much easier than having to calculate in the values Minimum and Maximum, as you are forced to deal with similar controls.

**Logaritmicity** - With "1" the scale is linear. With higher or lower values of one, you get a logarithmic or logarithmic inverse control. Plus the value moves away from one, the curvature is more pronounced.

**SmartResolutionFigures** - With "0" you get a normal numerical progression. Values from 1 to 9 indicate the number of significant digits. Set the numbers with the desired accuracy, but easy to read and remember.

**DefaultValue** - The "default", which is set when you click on the right button on the cursor.

**THUMBSIZE** - **ThumbRoundRectSize** - **BorderRoundRectSize** - Dimensions of the control of the cursor.

**Orientation** - **TickStyle** - Orientation (vertical or horizontal) and mark position (right, left, above or below).

**Value,Minimum,Maximum** - The value of the normal controls. Similar to those of Microsoft classical slider.

**SmallChange** - Increase to use with the Up Arrow

**LargeChange** - Increase to use with the PageUp and PageDown keys

**MouseEffects** - It sets to highlight the hover with a slight variation in color.

**MouseWheelSpeed** - Adjust to "1" for the minimum speed of the mouse wheel. With "0" you disable.

**ShowTextAlways** - You set to show the text even when the mouse is not over the control.

**TextColor** - Colour text - Clear to hide text.

**ColorRectangleBorder** - Colour Edge - Transparent to hide the edge.

**ThumbOuterColor** - **ThumbInnerColor** - **ThumbPenColor** - Mobile cursor colors.

**BarOuterColor** - **BarInnerColor** - **BarPenColor** - The border colors and the control body.

In addition to these properties they are also available with the normal properties, that all checks have DotNet base. For example, "Name", "BackColor" and the like.

## Appendix 6 - Evolution of radio receivers

The era of the wooden ...



... Iron ...



... Plastic ...



... And software.

