

theremino
•the•real•modular•in-out•

Theremino **System**

Theremin Synth Manual

What is it Theremin Synth?

This application is inspired by the musical instrument invented by Leon Theremin, called the Theremin, the first electronic musical instrument, the father of all synthesizers.

This software works even without hardware, you can download and try out its sounds. You can send commands and notes from the software, let it play with small programs in Theremino Script, connect sensors, **MIDI**, to MaxMsp or any music system via Slot, UDP and OSC.

The 'extreme efficiency of the current software, makes it possible to generate sounds with minimal hardware. A master module and two **CapSensor** (or just one), are sufficient, for a total of about 60 Euro.

You can also start with a single CapSensor, **spending less than 40 Euro**, and then add modules, sensors and capacitive buttons, to grow your own instrument without limits.

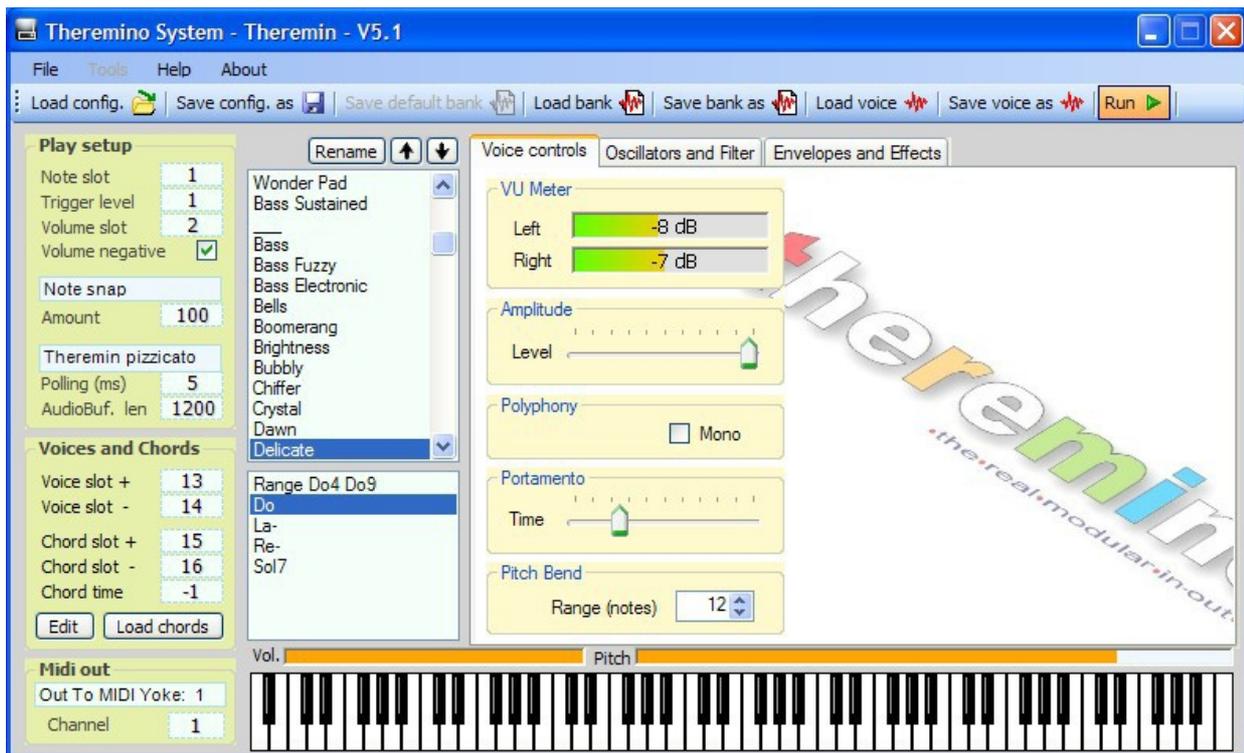
This software is also a test on how fast is becoming VBnet. The samples are generated one by one with mathematical calculations in floating point at 44kHz stereo and are applied to all the normal effects of a synth **OSCILLATORS, ADSR, FILTERS, LFO, and ECHO CHORUS**. The result is a true polyphonic synthesizer, but with a very low CPU consumption, practically almost zero, so that on a decent PC, you can run many Theremin, playing simultaneously.

With the **Theremino_Theremin** we tried to overcome the limitations of the original Theremin, in the following directions:

- Create voices richer than those that could be synthesized with hardware oscillators.
- Give the player the ability to "build" tones more suited to his style of music.
- Facilitate the maintenance of the pitch, hooking the frequency to the nearest semitone.
- Arpeggios are possible, over chords sequences (like the famous "harmonic circle")
- Possibility of playing chords, as if they were a single note, changing their pitch

The Theremino Theremin is built around two modules **CapSensor**, that make it very similar to a real Theremin (although more stable and linear). It can be played very well with a single antenna and fingers, connecting it to capacitive buttons and sliders of the **CapTouch** type, connected to all modules of the system **Theremino**.

Theremin Synth



The operation modes

Theremin Classic, Similar to the original Theremin instrument, but more flexible, thanks to the digital technology. To obtain the highest realism, we recommend to load the "Strings" preset.

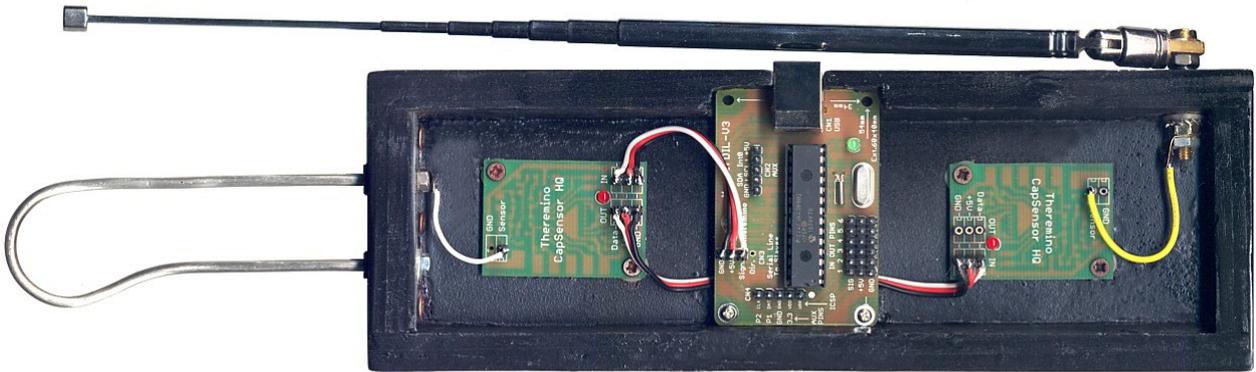
Theremin Pizzicato This method intones the notes at 100% and automatically uses only the notes selected by the "Range" and the currently selected chord. It is no longer possible to play out of tune, **even if you want, however, the possibility of changes and glides are limited. Tremolo and glissando are no longer possible.**

Poly Retriggered With this method, the Theremin is completely transformed, becoming a classic polyphonic synth, to be used with mechanical or capacitive keyboards. A keyboard can include three or four ON/OFF buttons and can be extended up to 128 keys, for a total of more than 10 octaves, with "Velocity" and "After touch".

Poly classic This method is even more similar to a classic polyphonic synth. Each time you press a key, the note is triggered only once, to make better use of the classic ADSR envelope controls.

Radioactivity Almost identical to the previous Polyphonic mode, but optimized for the Gamma Spectrometry software, ThereminoMCA. Each note of the scale of the piano, is associated with certain radiation energies, allowing to distinguish radioactive isotopes, from their sound.

Required Hardware



Just connect a Master and two CapSensorHQ and the Theremin is ready!

To build the antennas, you can use an electric wire, a metallic tube or any other object, even as little conductive as ***a banana, a glass of wine or a vase of flowers.***

It is recommended to **divide pretty much the two antennas** (at least one meter, to avoid interference between the movements of the two hands) and to build the left antenna much larger than what you see in these pictures.

It is not strictly necessary to make a classic Theremin with the classic two antennas setup, given that the Theremin Synth, has a function of automatic "Staccato" and can be used with a single CapSensor, releasing your left hand for other, easier to adjust controls, such as sliders and capacitive buttons.

With capacitive keys, you can "build" keyboards and musical instruments, never seen before. With sliders you can adjust effects such as, for example, the filter of the sampler **Theremino SoundPlayer**, to get a good WahWah effect.

Possible expansions are endless, limit is only in the number of controls, that you can handle in a coordinated way.

Theremino System is not only a Theremin, but a complete system of Inputs Outputs, that makes possible building musical instruments with "**Inputs**" of all kind, from magnetic fields, to light, webcams, pressure, up to electrical resistance. See: www.theremino.com/hardware/inputs

The software is completely free and open source, **the latest version of the program is always available here:** www.theremino.com/downloads/multimedia

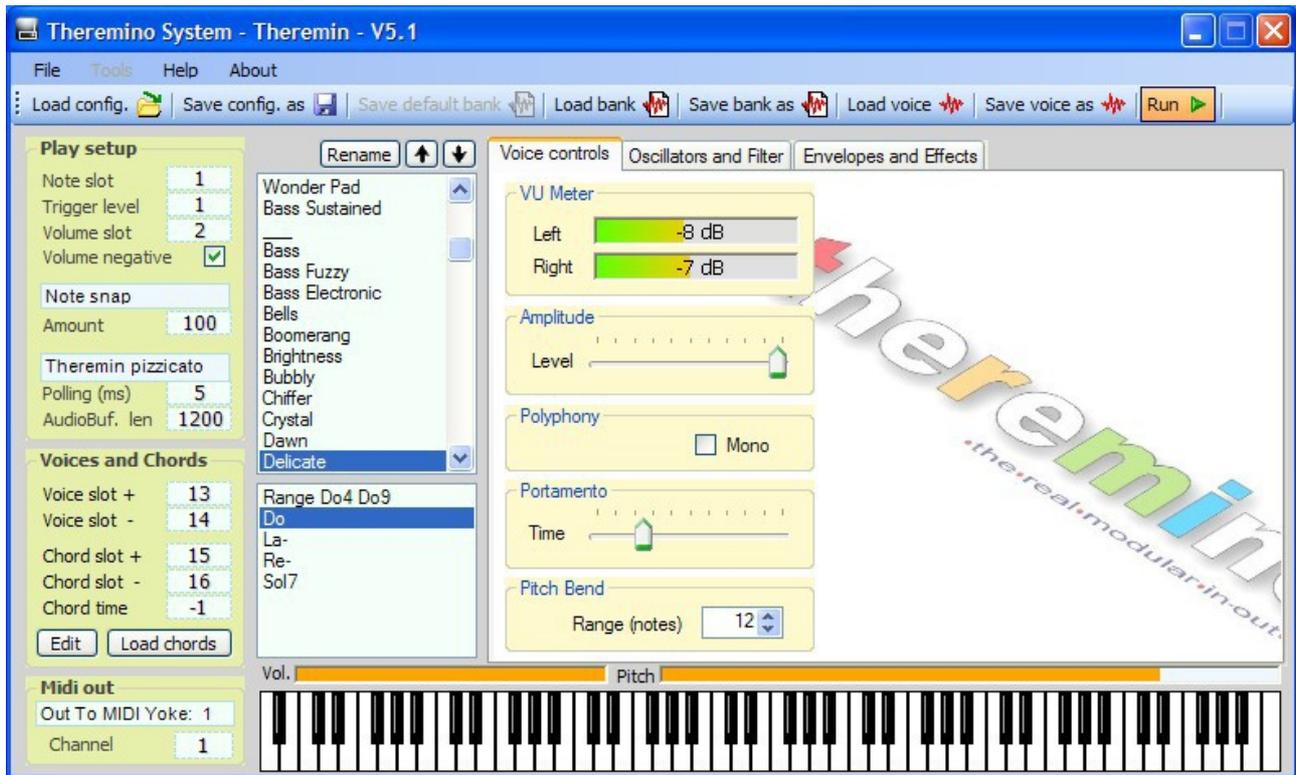
Attention: To access to the hardware of Theremino system via USB, you must use the software HAL (Hardware Abstraction Layer) as well, that can be downloaded here: www.theremino.com/downloads/foundations

Up to six sliders and capacitive buttons can be connected to the pins of the Theremino Master.

You can start right away, with just a Master and a Cap sensor, spending less than 39 Euro.

(www.theremino.com/contacts/price-list)

The main areas of the program



- ◆ On the left, overall adjustments.
- ◆ In the center, the list of "Voices" and the "Chords" list.
- ◆ To the right, adjustments to the single "Voice".
- ◆ A keyboard, marks the notes you're playing and can be pressed with the mouse, to easily test sounds.
- ◆ On top of the keyboard, two stripes indicate the signal coming from the volume and pitch antennas.



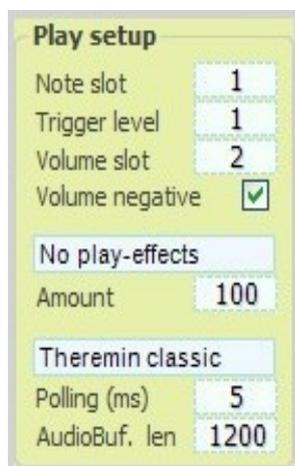
The piano-style keyboard, used in **Polyphonic** and **Radioactivity** modes, indicates the notes that are played with an external keyboard and allows you, to try the sounds with the mouse, as well.



In **Classic Theremin**, **Theremin Legato** and **Theremin Pizzicato**, modes, to the normal keyboard, two stripes are added, marking the distance of the hand from the antenna with a filling of orange, indicating the note you're playing and its volume.

The general configuration

With this box you can choose the operation mode. These are explained, one by one, in the first page of this document.

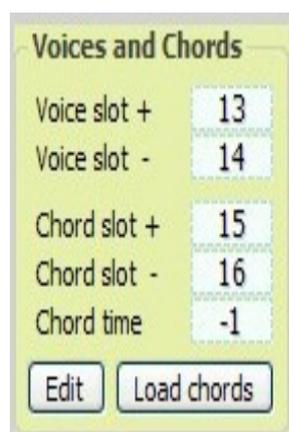


- Input slot of the note or the first slot of a group of notes. (Note 1)
- Minimum signal level to activate the notes.
- Volume input Slot.
- Negative Volume (Used in Theremin modes only)
- Performance variations
- Frequency of data reading. (Note 2)
- Audio buffer length, in bytes. (Note 3)

(Note 1) In polyphonic modes, "Notes slot" is the first slot of a number of consecutive slots. The total number of slots depends on the range of notes "Range"

(Note 2) This value is normally set to 5 (maximum speed of response) but you can rise it, to save work to the CPU, or to make more pleasant the sequence in "Radioactivity" mode (to highlight and make more pleasing the sounds produced made by radioactive isotopes. (it is recommended to use a "polling" of about 200 or 250 ms)

(Note 3) A sound buffer of 2000 bytes it is normally fine on all computers. If you hear strange noises in the voices, you could increase this number, to make them disappear. Try at least once, to lower it to a minimum, to hear the kind of disturbances that occur and be prepared to recognize them. This control should always be at the minimum necessary, to safely get rid of the noise. The more you increase this number, the more the synth becomes slow in the execution of notes and commands.



- Slot input to switch to the next voice
 - Slot input to switch to the previous voice
 - Slot input to switch to the next line, in the list of chords and intervals
 - Slot input to switch to the previous line, in the list of chords and intervals
 - Time for the automatic transmission of the chords
 - Selection of the list of chords and intervals (a sort of score)
- "Edit" opens the folder of the list of chords. Double-click on it, to open the file to edit.

Changes of voices and chords by external applications

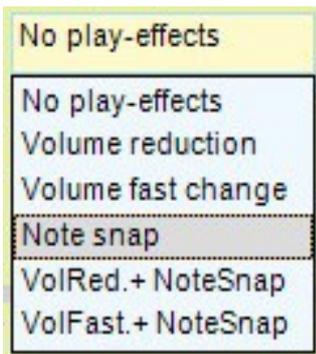
External applications (eg Theremino Automation or Theremino Script) can set directly voices and chords through the Slots: "Voice slot +" and "Chord slot +". The number to be set in the Slot is the Voice or Chord order number, plus ten thousand. So 10000 means 0 (the first entry in the list), 10001 means 1 ... and so following.

Performer variations (play effects)

This page , shows the changes on version 5.1, there may be some additional changes, in the next version, which will be explained on the download page.

Some of these variations are experimental , we are making adjustments to improve them. In some cases , the instructions given in this manual , may be inaccurate, please refer to the download page, for more information.

The adjustments in this panel only act in the " Classic Theremin " mode



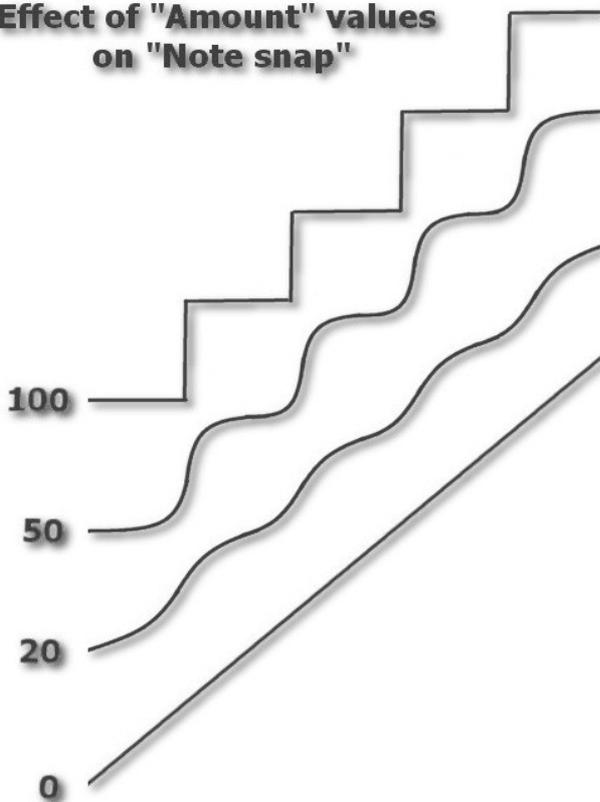
No play effects - No effect of changes in the performance.

Volume reduction - This is an effect of automatic "note off", which lowers the volume when you change note and restore it, as soon as you stop moving.

Fast Change Volume - This effect increases the volume changes when you move your left hand quickly .

Notes Snap - This effect helps the musician , with an algorithm that facilitates catching the pitch of notes . Effects of glissando and tremolo, are still possible but the sound is less "whining" and the notes stay in tune .

Effect of "Amount" values on "Note snap"

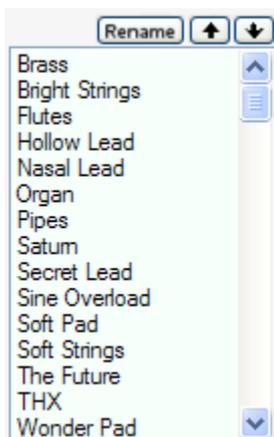


This image shows the effect of "'Amount'" on the "Snap" in the notes.

With a high amount, notes are tuned with force to the nearest semitone. Unfortunately, under these conditions, you no longer feel when you are away from the center of the note and it can happen to jump on the nearest one, by mistake.

With a low Amount, the help you get is lower, pitch and is therefore less accurate.

The list of presets



The default voices are only examples, every musician should create his own, best tailored for the music they play.

The commands to save and reload, rename, and move single items, allow you to organize items in a workbench called "Default".

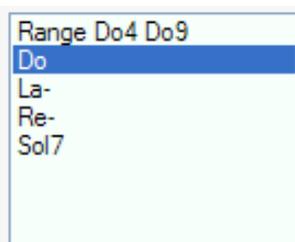
Normally only one bank is well organized -**the Default bank**-, with well planned sounds, easy to remember, always loaded at the start of the program.

Any sound bank, can be saved to disk and restored, but only the "Default" bank is automatically loaded at the start.

A bank contains 129 voices, which normally fall into two main groups, depending on, whether or not they are "Sustained". Items with "Sustain", continue to play indefinitely, while the others, decrease in volume gradually to zero.

The selected item can be changed at will, with the controls on the panels "Main controls", "Oscillators and Filters" and "Envelopes and Effects" which will be explained in the next pages.

The list of chords and notes intervals



This list defines the valid notes.

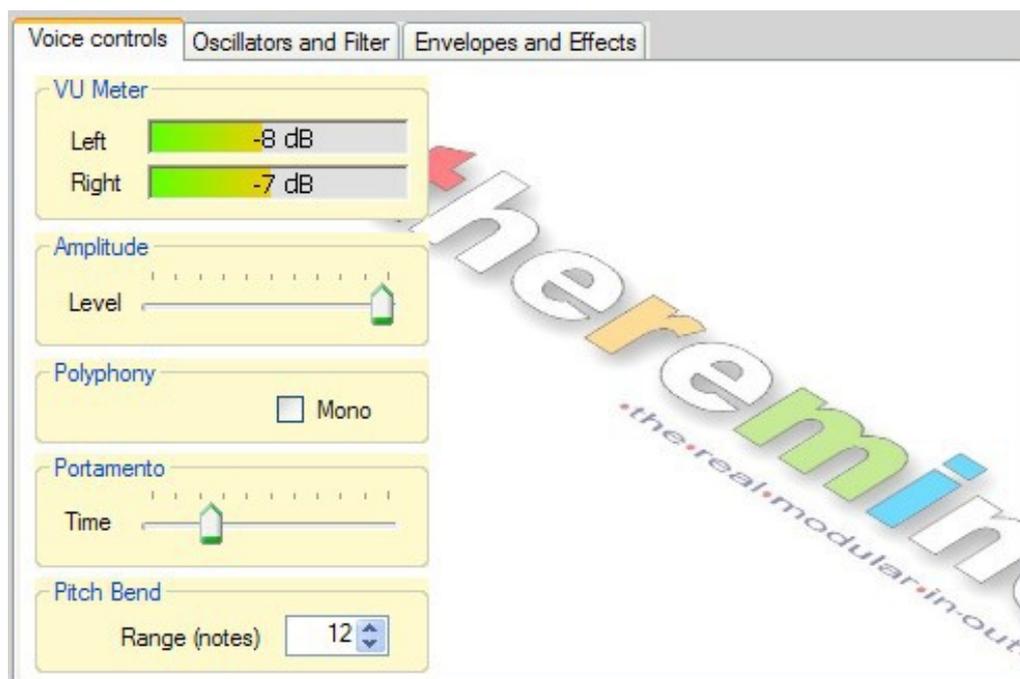
On the image of this example, the notes are limited to a range from C4 to DO9 and chords are set as C, A-, D-, G7, the famous "C harmonic circle"

The notes are only valid in the range defined by the "range" and included in the chord currently selected.

Starting from the first note of the range, the notes not valid, are "jumped"

This list is not in use in modes "Theremin classic" and "Theremin Legato", but only in "Theremin pizzicato" and polyphonic modes.

Voice modifying - Main controls



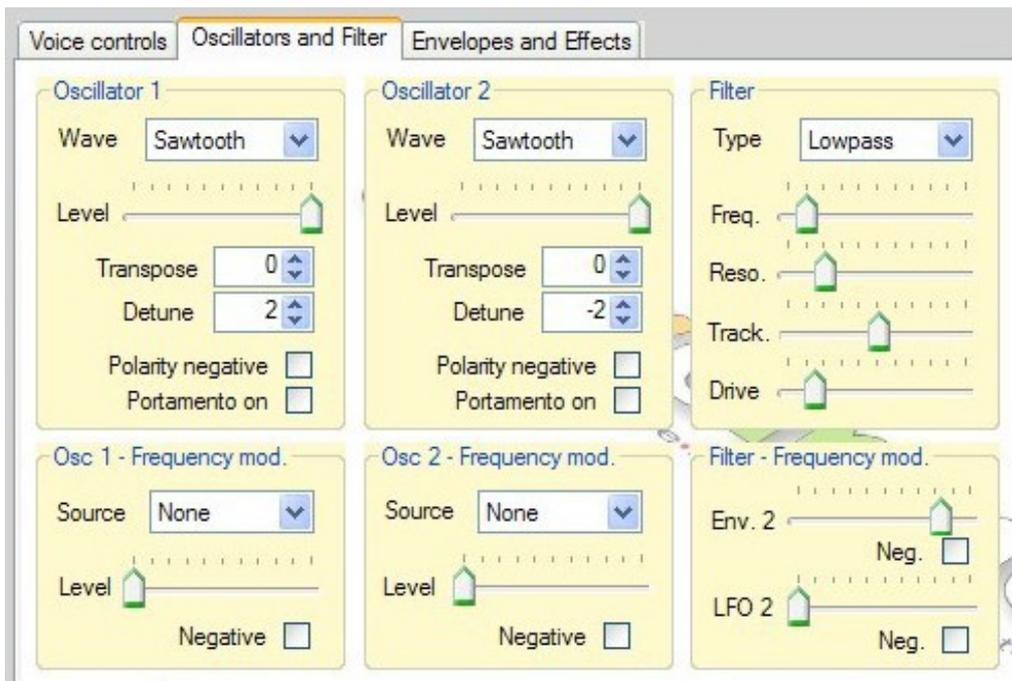
Adjust "Amplitude" so that the **VU meter** does not rise too much, in order to avoid distortion. This adjustment also depends on the manner in which the voice is played. In general, if you play in polyphonic mode, you have to keep a lower level of **"Amplitude"**.

Disabling the polyphony This panel, has no relation to the general modes of operation of the synth, is just related to the single entry. If you press **"Mono"**, only the last note is played and the previous is immediately muted.

"Portamento" performs a gradual transition between notes. This parameter affects only those presets that have at least one oscillator, with portamento enabled.

The "pitch bend" defines the way of action in the "Theremino classic" and "Theremino legato" modes and the range for the MIDI controller called **"Pitch Bend"**. Compared to the note being played, the tone is raised and lowered for the number of notes set. If you set **12**, the total interval, will be **one octave** below and one above.

Editing voices - Oscillators and filter



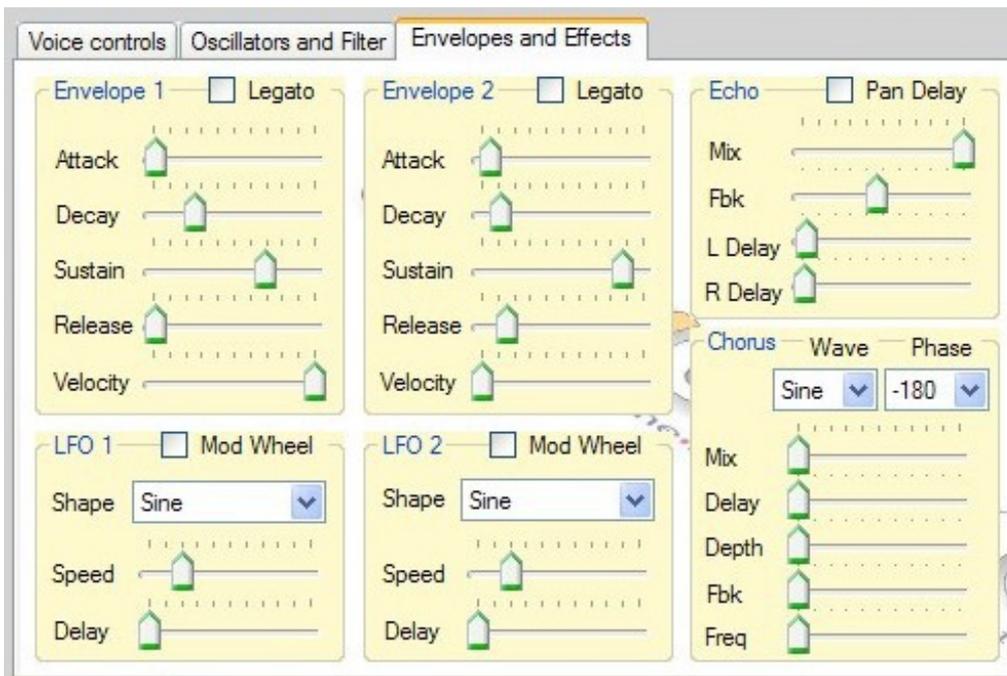
Oscillators and filters are at the heart of the synth.

ThereminTheremin, can be considered as a hybrid synthesizer. It is based on **wavetable/Additive** synthesis, but includes traditional analog modules (filters, LFOs and envelopes) of a typical **subtractive synth**, as well.

The filter is a "**state variable filter**", also a classic, easy to use and a great complement to this synth.

We will not explain how to adjust these controls, as there is no rule really. Any combination of adjustments is valid and a good musician should know how to get the best sounds for his music.

Changing Voices - Envelopes and effects



The "**Envelopes**" are normal "**ADSR**" generators and are used to set the volume of the voice over time, or to modulate the frequency of the oscillators.

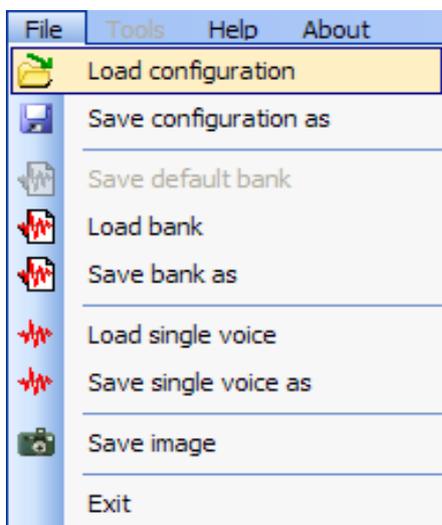
The **LFO** oscillators are low frequency modulators, that can be used to modulate the frequency in the oscillators.

Echo and Chorus effects are true classics, perfect for making full-bodied voices. Be careful not to use them too much, they should just give substance to the sounds and do not act as "environment" effects.

The lack of other filters as Reverb, Flanger is not a defect. In the instrument there should be only the effects for the individual voices, the environment effects, should be applied in the mixer instead, or in the sound system, to have more control of the various sounds, in the same environment.

With these controls, there is no rule at all, any combination of adjustments is valid and a good musician should know how to adjust the voices, for his music.

The commands on the File menu



The "**configuration**" includes all adjustments of the configuration panel (note 1)

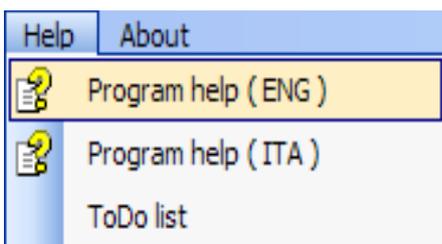
Commands to save and restore the Voices banks

Commands to save and restore the individual voices

Images are useful, to exchange information and advices. Preferably use images with visible settings.

(Note 1) Reloading a configuration, also restores the selected voice and the list of chords, so that the operation and sounds are the same, as when the configuration was saved. If the default bank has been changed, then the sound will be different.

The commands on the Help menu



With these commands you can access to the program documentation.

The documentation is currently only in English, Italian and Spanish. In the future will be translated into other European languages and Japanese.

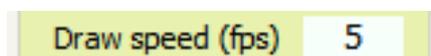
The toolbar



The buttons of the toolbar, allow faster access to frequently used commands.

These commands are a copy of the File menu commands, except for "Run" which is used to enable and disable communication with the outside world and as a "Panic Button", to stop any sound.

Adjusting the numerical boxes



The numerical boxes of Theremino MCA (and all other System Theremino applications) have been developed by us (note 1), to be more comfortable and flexible than the original Microsoft TextBox.

The numerical values are adjustable in many ways:

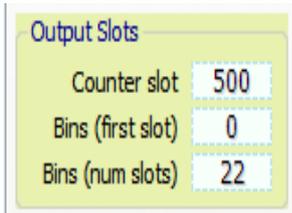
- Click, hold down the left mouse button and move the mouse up or down.
- With the mouse wheel.
- Using the arrow up and arrow down keyboard keys.
- With conventional methods used to write numbers with the keypad.
- With conventional methods of selection and copy-paste.

- ◆ Moving the mouse up and down allows large and fast regulations.
- ◆ The mouse wheel movement, allows convenient and immediate adjustments.
- ◆ The arrow keys allow fine adjustments, without having to look away from what you are adjusting.

(1) Like all our software, source files are available (Freeware and Open Source licensed under Creative Commons) and can be downloaded from here: www.theremino.com/downloads/uncategorized (Section "Custom controls") These programs can be used freely in any project, without necessarily naming the source. The "Open" source also serves as a guarantee, that we have not included malware.

Playing with isotopes

In the ThereminoMCA application, please adjust the output slots, as seen below.



- Slot to send the counts to (usually towards Thermino_Geiger)
- First slot to send the counts divided into bands
- Number of "Slots" and then, row of consecutive bands

"Counter slot" Used to send the total count to a TherminoGeiger and make quantitative measurements, even with a photo multiplier tube, as if it were a normal Geiger tube, but with much higher sensitivity.

"Bins (first slot)" and **"Bins (num slots)"** are used to divide in zones the spectrum (only the visible part). The sum of the counts of each area, is sent to a number of consecutive slots, so that other programs can use these data in real time.

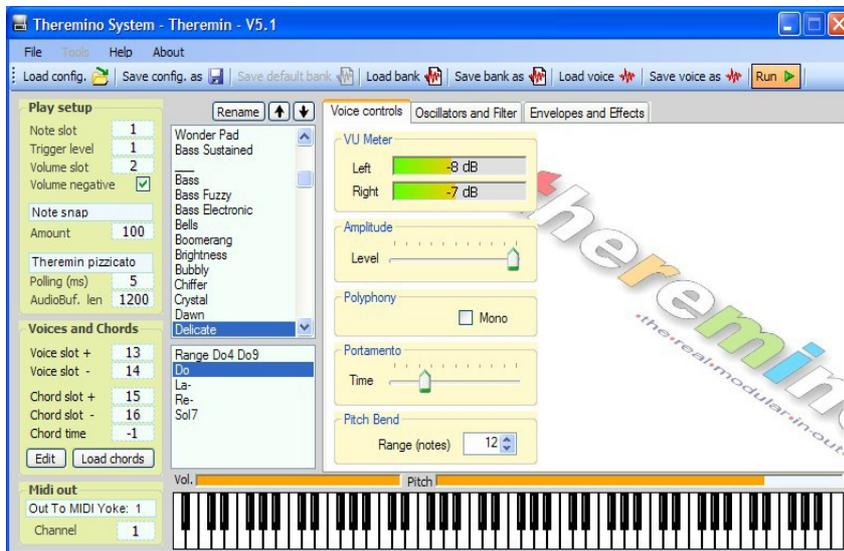
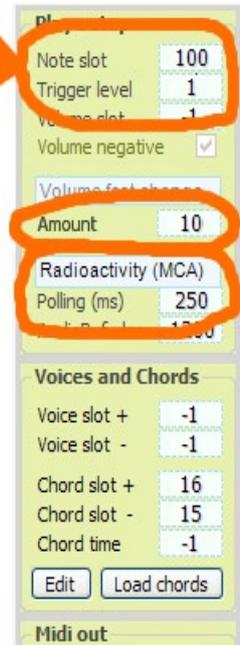
In Theremino_Theremin, adjust the **"First slot"** to **100** (same number as the "first slot" of ThereminoMCA)

Control "Amount" adjusts the volume, compared with the levels of radioactivity.

Theremino MCA



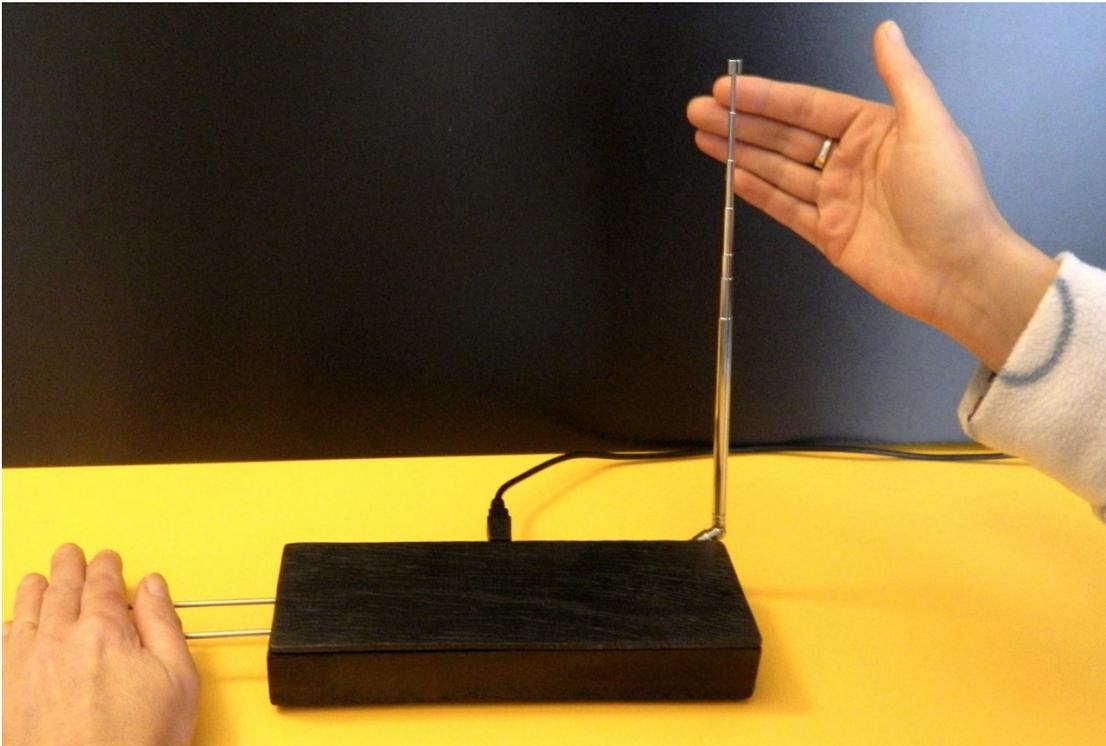
Theremino Theremin Synth



Set a "Polling" time of around 200 ms and the proper range of notes.

It is possible to change sounds and chords, choose a "Harmonic Circle" or set a time for automatic chords change "AutoChg(ms)", from about 2000 to 4000mS, to liven up and make harmonious, the boring raw data produced by radioactive samples .

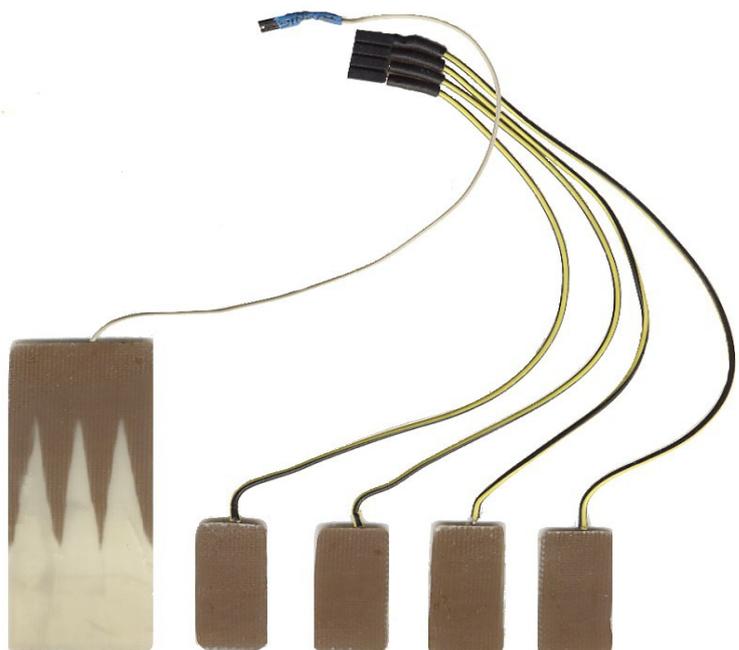
Playing the Theremin



The Theremin is a very difficult instrument to play, using "Note snap" and "Volume reduction" modes, things get a bit easier..

Only true virtuosos can play it, using the left hand as well... a tip for them: **separate very much the antennas** (at least one meter, to avoid interference between the two hands) and make the left antenna, much larger than what you see in these images

It is advisable to normal musicians, (those who are not called Pamela Kurstin), to reserve your left hand to capacitive buttons and sliders, much easier to use.



Capacitive buttons and sliders



They can be constructed easily by cutting, even by hand, from a sheet of single face copper **Vetronite**.



The keys are played on the non-copper side and can be covered with a thin sheet of paper, printed in color and plastic coated, to give a professional appearance to the keyboard. In this case, to limit the thickness of the insulation, turn them with copper up .

You can cut the edges with a saw, copper is etched with an utility knife , or eventually, make a real printed circuit board with all the keys you need, on a single board.

For connections, use regular electric cable, in small diameter and isolated. The length of the wires should always be kept to the minimum possible, as even the wires are sensitive. Shielded wires cannot be used, as the electric capacity would increase too. If any part of the instrument, must be very far from the Master, then you should get to the place, with a serial line and then connect up to ten capacitive keys with a module called "Servo".

To greatly increase the number of keys, you can use multiple modules **Servo**, for **up to ten keys each**. Beyond a certain limit the serial line slows down. In these case, it is necessary to use more Masters and use, if possible, 8-bit pins, rather than 16.

The capacitive keys, can be connected to a sampler as **Theremino SoundPlayer**, sent to MaxMsp or generate OSC (Open Sound Control) messages, that can be played with any professional tool, via UDP, local network or the Internet, even on Mac OSX computers, Linux or Android. See: www.theremino.com/downloads/foundations

ATTENTION: To access Theremino's system hardware via USB, you must use the software HAL (Hardware Abstraction Layer) as well, that can be downloaded here: www.theremino.com/downloads/foundations

The capacitive keys, can be connected to a sampler as **Theremino SoundPlayer**, sent to MaxMsp or generate OSC (Open Sound Control)

Tips to avoid feedback, between the antennas

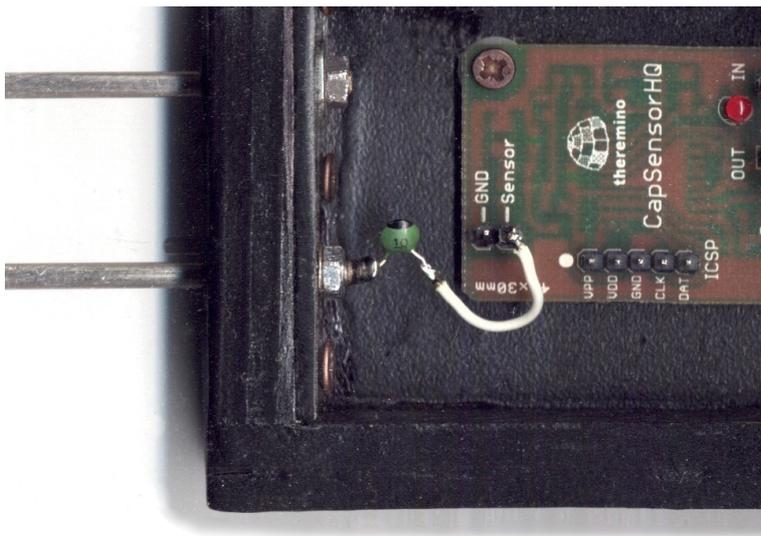
Antennas lengths and some other random factors, can bring to a situation where both, volume and notes antennas, work on the same frequency. This coincidence only rarely happens, but can be very annoying. The two antennas operating on the same frequency, may interfere with each other, causing interference on the note, when moving the left hand.

To avoid this, first of all check the antennas frequencies, in the **HAL** program. Double click with the left mouse button on the line of the first **CapSensor** (first arrow on the left). Then do a single click, with the right mouse button on the second line, named **CapSensor** (first arrow on the left). Finally, check if the two frequencies, indicated by the orange arrows on the right, are different (say at least 100 kHz).

The screenshot shows the Theremino HAL software interface. The main window displays a table of configurations for Master and Slave devices. The Slave 2 configuration is highlighted, showing a CapSensor on Pin 1. The Slave 3 configuration is also highlighted, showing a CapSensor on Pin 1. The Pin properties for the selected CapSensor are shown on the right, including Pin Type (Cap_sensor), Slot (1), Max value (1000), Min value (0), and Response speed (30). The Cap sensor properties are also shown, including Max dist (500 mm), Min dist (50 mm), and Area (50 cmq). A graph on the right shows the frequency response of the two antennas, with the volume antenna (red) and the note antenna (blue) showing different frequencies. The graph has a vertical scale from 0 to 1000. The data table below the graph shows the raw and normalized values for both antennas.

M:1 S:3 Pin:1	M:1 S:2 Pin:1
Raw: 425261	Raw: 411526
mS: 26.5788	mS: 25.7204
MHz: 2.46572	MHz: 2.54802
C_tot: 12.625	C_tot: 11.823
C_in: 00.000	C_in: 00.000
mm: 0250	mm: 0250
Norm: 0.00	Norm: 0.00

To solve a problem of interference, just add a 10 pF capacitor, in series to the volume antenna wire.



This capacitor, sets the volume antenna to a higher frequency (it's always better to have the antenna volume, at higher frequency than that of the note). It also has the beneficial effect of avoiding the oscillator volume, from causing noise, when the antenna is touched.

Tips to avoid interference from external sources

The oscillators of the CapSensor, work from 2.3 to 2.6 megahertz. This is an area pretty free from radio interference, being before medium and short waves. Mobile phones, cordless phones and WiFi do not interfere at all. CapSensor cards are also immune from powerful radio emissions, CB and amateur radios.

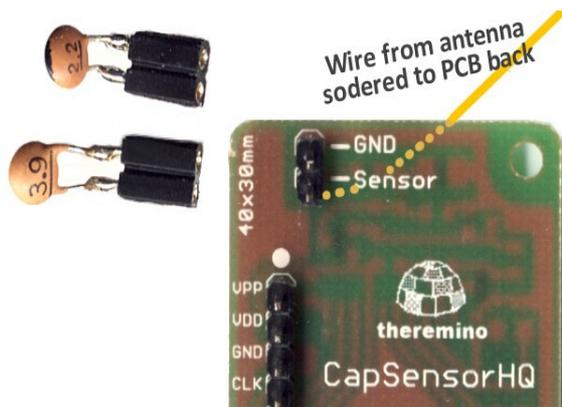
The emission power of the CapSensor, is much smaller than that of the Moog Theremin (and therefore a lower electrical pollution to the surrounding environment), but the downside is that the oscillators of CapSensor, are much more sensitive to noise, than those of a Moog Theremin. There is therefore the possibility that a strong radio broadcaster, who eventually falls exactly on the same working frequency of one of the two antennas, can cause disturbances. Even a Moog Theremin can be affected, but it would probably be much less.

In some rare cases, some little and repeated disturbances were observed, sometimes lasting for hours and suddenly disappearing. We think there could have been some unusual transmission, not listed in the normal frequency tables, using the same range we used, but we've never been able to verify this.

In case of problems, you could add a small capacitor **in parallel with** the pitch antenna. **(Between signal and ground)** Only the pitch antenna is important because the noise is minimal and in any case, even if they are not audible on the volume.

Adding a pF 2.2, 3.9 pF or pF 4.7 capacitor, causes slight drops in frequency, this way you should find an area free from interference. **Be sure they are pF**, if you make a mistake and use capacitors of nanoFarad or microFarad, the antenna does not work anymore or loses almost all of its sensitivity.

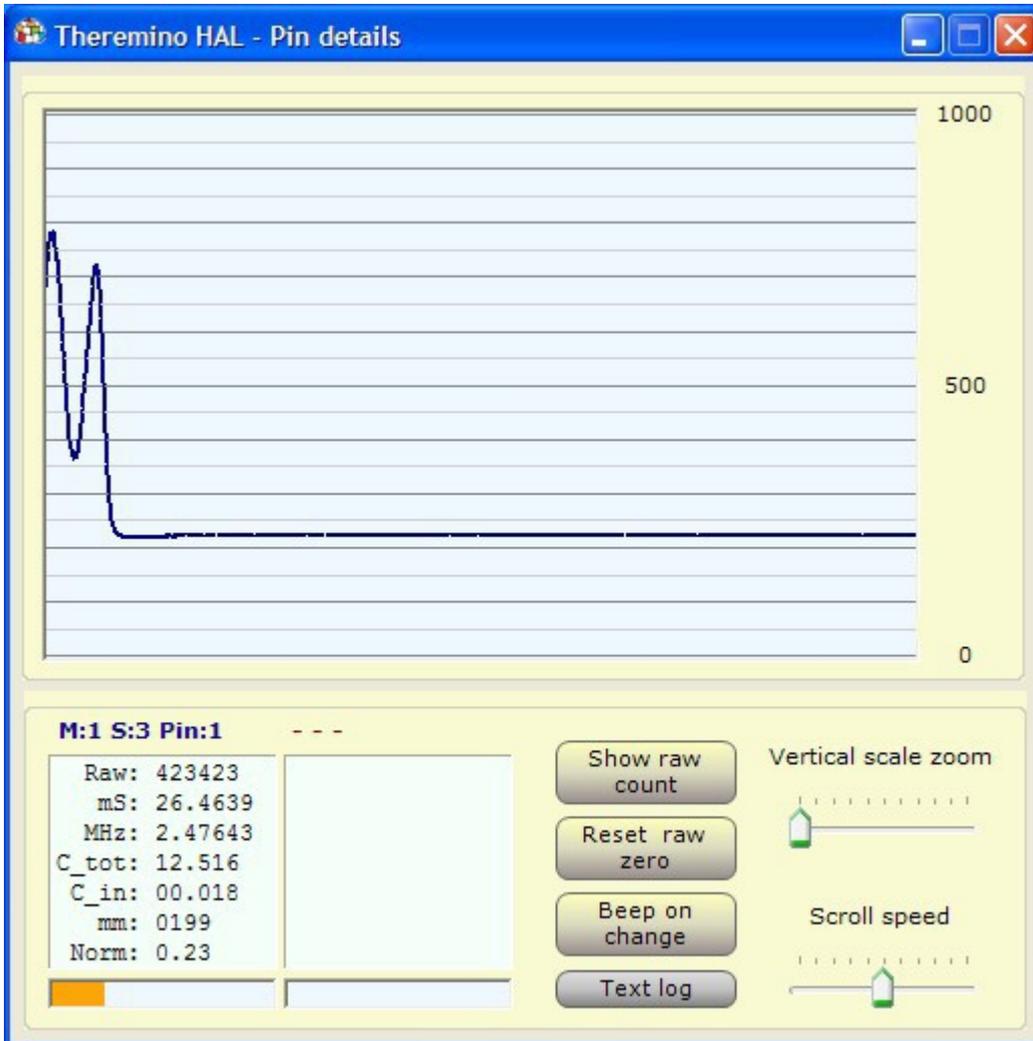
Don't worry too much about these observations, in reality it almost never happens, however **it wouldn't hurt to get a few pF capacitors** and prepare a socket for emergency cases, for example when playing next to an Army transmitter, which transmits on the same frequency of the pitch antenna.



Solder the cable to the antenna, from below the PCB in order to free up the male connectors and only use female connectors prepared as indicated on this page: www.theremino.com/technical/connection-cables

Tips to avoid note jumping and random noises

You can have interference from any of these cases: Even minimal movement of metal parts, a wood torsion, a not perfectly fixed antenna, female connectors not making perfect contact or that turned bad, just moving your legs under the table or a movement of the mouse, the table twisting or the audience too close.



HAL application, provides a sort of oscilloscope to test the stability of the oscillators. Please, get used to it and check that everything is working, making some tests with the **HAL**.

Try to move and twist all the mechanical parts, before rely on them. Also, try to keep everything firm and make sure that the line is free from disturbances, such as in the right side of this picture. A maximum of one pixel of noise can be tolerated, as the step in the left, before the horizontal part.

Before making important performances, prepare an adequate workspace and double check, the stability of all components.



Those interested in learning how to play Theremin, should definitely watch this video, from start to finish!
www.youtube.com/watch?v=X-ywH1Vj8_U#

Here you can see the Theremino Synth played by a failed musician! (be good with me, the video serves only as a demonstration of the features of the Synth): www.youtube.com/watch?v=QW7Xhh9nijo

We will post more videos soon, on the [Theremino System](#) channel, that will show even the individual voices, the capacitive buttons and sliders.



For information, advice and training on the Theremin, we recommend the fantastic site [Theremin World](#) a mine of useful information, the center of the world for the Thereminist.

Conclusions

- ◆ Music, is the best medicine for the soul - *Plato*
- ◆ Electronic music, is the best medicine for the Nerd - Livio

Nerd - Person with a predisposition for intellectual research, usually alone, with a much reduced propensity for socialization. The Nerd, can spend an enormous amount of time in obscure and unpopular activities, which are generally related to very technical areas, or fiction and fantasy, with the exclusion of more traditional activities.

That vibrations, be with you!

Max & Livio