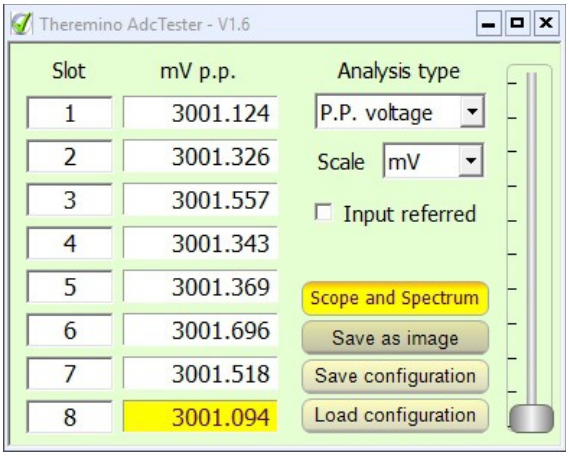
Theremino **System**

Theremino ADC Tester instructions and notes

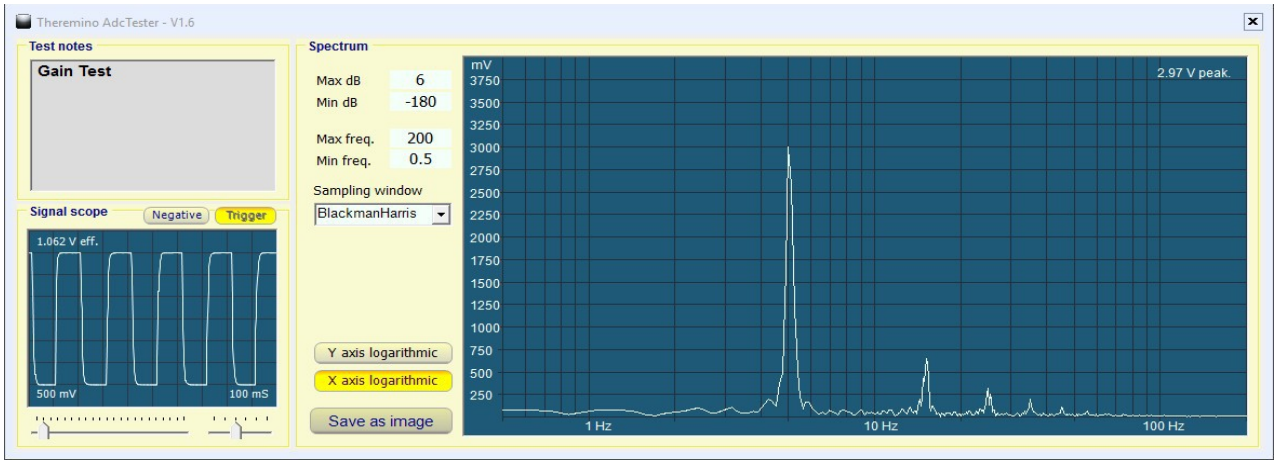
Main index

The “Theremino AdcTester” application

During the first tests doubts have arisen about the characteristics of Adc24, so we wrote this app to measure them and check that correspond to the design specifications.



Subsequent tests have given values in accordance with the data-sheet characteristics and in some cases even better. Also all copies of Adc24 and all channels gave very similar values to one another.



- The noise, with a gain of 128, sampling speed of 600 SPS and three channels differential, closed on 400 ohms (impedance of geophones), result at 0.17 uV eff., then only slightly higher than GeoPreamp they had a noise 0.10 uV eff.
- The channel gain on the same Adc24 was identical within +/- 0.01%. The gain differences between different Adc24 inputs were in the order of 1%. This 1% is not due all'Adc24, but it corresponds exactly to the tolerance of the reference voltage to 3.3 volt stabilized by the AP2210 that has the 1% accuracy in the characteristics.
- The intermodulation between channels was extremely low, few nanoVolt, even under the worst conditions: Square wave of 3 V pp applied on seven inputs - Two inputs strongly saturated due to their gain of 128 - The only input that it is not applied to the signal located between two disturbing inputs. - All the test settings as for the measurement of noise.

It is not necessary for users to make these tests. The Theremino system Adc (16 and 24 bit) are simple (few external components to the main chip), for which you can hardly occur partial defects, in practice or work or not work. However, if in doubt, just check them for with this application and a few readily available components. In the next few pages we'll explain how to perform the measurements.

Possible tests

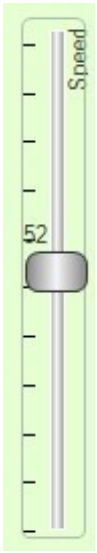
With the AdcTester you can test the gain, the background noise and the intermodulation between the channels, both of the ADC 8 and 16 bits, that of those 24-bit. In this document we will explain in detail how to perform the tests for the “Theremino Adc24”.

Slot	uV eff.
1	0.38
2	0.34
3	0.33
4	0.00
5	0.00
6	0.00
7	0.00
8	0.00

You can measure simultaneously up to 8 channels. Each channel is read from a Slot. Normally the slots are from 1 to 8, as in this image, but it is possible to change them. Experts of Theremino system can then also measure other signals, on any Slot from 0 to 999.

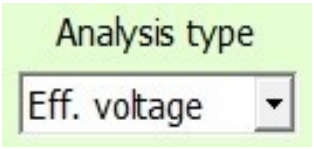
The value highlighted in yellow is also sent to the oscilloscope and spectrum analyzer (if they are active).

The vertical bar "Speed" is used to adjust the integration time of the measures. By raising the settling time decreases, lowering the numerical values become more stable.



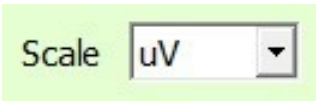
The possible measures are as follows:

- Medium voltage
- Peak-to-peak voltage
- Effective voltage (true RMS)
- Number of bits free from the noise (N.F.B.)
- Signal to noise ratio in decibels

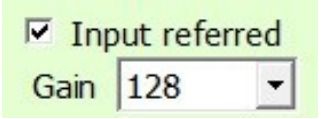


Voltage measurements can be calibrated in the following scales:

- Volt
- milli-Volt
- micro-Volt



The measures may also take into account the gain of the pre-amplifier and in this case the measured values are "input referred".

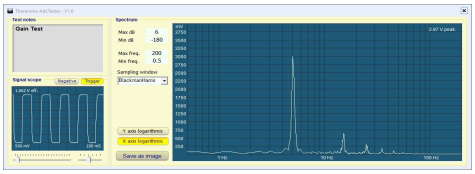


The gain values from 1 to 128 correspond to the Adc24 programmable amplifier settings.

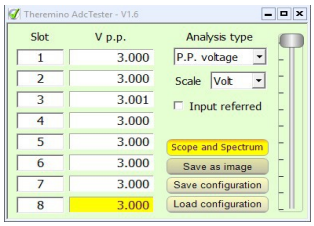
The gain values from 200 to 10000 correspond to the normal settings of GeoPreamp. attention that the GeoPreamp must not be connected to the Adc24 but to Adc16 that are on the Master.

The command buttons

Scope and Spectrum - Opens and closes the oscilloscope and spectrum analyzer window.



Save as image- Save a snapshot image of the main window of this application (as the picture on the right). The oscilloscope window and analysis of spectrum is not included in this image. To save it there is a special button near the oscilloscope.



Save configuration - Save all configuration parameters, including even the oscilloscope and the spectrum analyzer settings. It is recommended not to edit files "Adc24_GainTest.txt", "Adc24_NoiseTest.txt" and "Adc24_ImodTest", but to give a personal name to the file. ***(Note 1)***

Load configuration - Upload all configuration parameters, including even the oscilloscope settings and the spectrum analyzer. This command prepares for a fast ride testing tool. Remember that, depending on the tests to be carried out, it must also properly configure the HAL ***(Note 1)*** and the Adc24 selection jumpers. And that for the gain and intermodulation measurements you must also start the "Wave Generator". All this will be explained in the individual tests, in the following pages.

(Note 1) *It is good to note that when you change a parameter in the HAL the new value is edited directly in the "Configuration" currently in use. So the HAL behavior is different from that of the AdcTester, that remembers the changes in the "Theremino_AdcTester_INI.txt" file.*

Details on the measurement sets

Changes to the measure sets

The measure sets prepared by us are the starting points for the three key measures:

- Noise
- Intermodulation
- Gain

But those who have experience in electronics can use this application as a generic tester and make changes to these tests. In this case it is advisable not to change the basic configuration files, but create new ones, with a personal name. In the HAL you create new configurations with the "Name" button, instead in the AdcTester are created with "Save configuration".

Adjustments in the HAL application

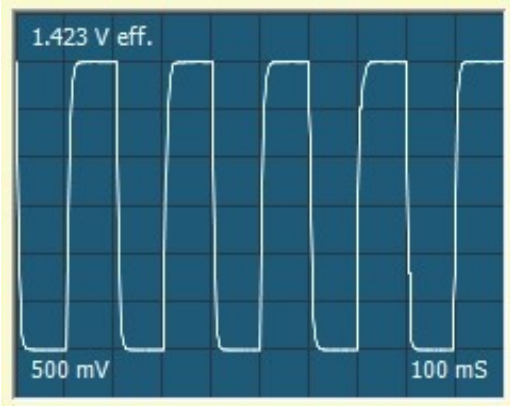
The "Theremino AdcTester" reads the slot values coming from ADC and expects that these values are expressed in Volt. So in the HAL application the MinValue and MaxValue must be set as follows:

- With Differential inputs (Adc24) MinValue = -3.3 MaxValue = 3.3
- With Pseudo inputs (Adc24) MinValue = -1.65 MaxValue = 1.65
- With Single-Ended inputs (Adc24) MinValue = -1.65 MaxValue = 1.65
- With Adc8 o Adc16 inputs MinValue = -1.65 MaxValue = 1.65

Note that Adc24 can be configured in three types while Adc8 and Adc16 are always single-ended.

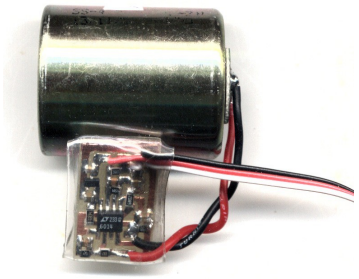
Gain measures - Benefits of a square wave than a sine wave

- The measured values are more stable, given that there are no errors due to mismatches between the sampling instant and the the sinusoid maximum point.
- The perfectly horizontal upper and lower segments indicate that the passband extends to very low frequencies. This is a fairly obvious confirmation, since the Adc24 certainly comes down to zero Hertz.
- The almost perfectly vertical rising and falling edges indicate a good response at high frequencies.



Measuring the noise collected by cables

The Adc24 measures have shown that microtremor data defects are not to be attributed to noise, nor to intermodulation and even to the gain differences between the channels. Subsequent tests have shown that the noises originate from connections between the geophones and the Adc24 inputs.



This problem with GeoPreamp was less serious because they were positioned near the geophones and sensitive wires were short.

Instead the wires ranging from geophones to the Adc24 are necessarily long at least fifteen centimeters. And in some prototypes, as we were not aware of this problem, the wires were long even more than twenty centimeters.

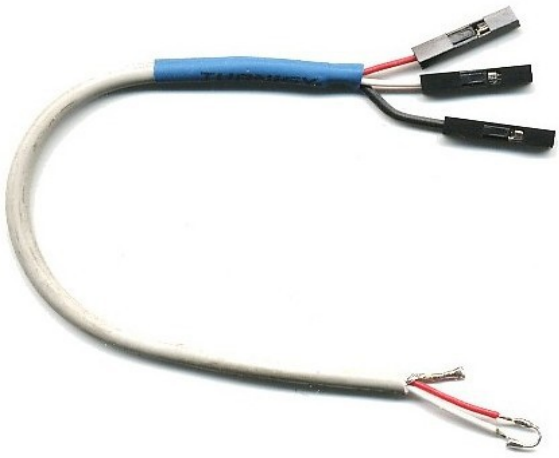
To measure the amount of noise picked up by the unshielded connections you can not connect them to a geophone, because the vibrations, always present even in less noisy environments, distort completely the measures, but you must do the following:

- Prepare everything as for noise measurements.
- On one of the inputs, instead of the jumper, connect two wires long 10 or 15 centimeters.
- Close the two wires at the end, that is, put them into short, instead of connecting them to the geophone.

The channels with the jumper should give about 0.17 uV eff., while that with the wire a much greater value, depending on how close it is to electrical appliances or to the wires of the electrical installation. Approaching a hand to the wires these noises should increase.

You should also note, in the analysis of the spectrum, that the noises have focused on some frequencies. And it is these frequencies that disturb the analysis of micro-tremors, as they seem to break ground layers, or resonance frequencies of the buildings.

If you repeat the experiment with a shielded cable at the closed end, you should measure a noise values similar to those that are measured on the channels closed with the jumper.



Connect sensors with shielded cables

Here you see an example of a sensor connected with shielded cable. In this case it was also added a 4.7 uF capacitor (the small rectangle welded between the two electrodes of the geophone) Which limits the bandwidth to 150 Hz. This filter prevents the high frequency noise being shifted to low frequencies (from 0 to 100 Hz) from the aliasing phenomenon.

A further and important aliasing reduction is obtained by increasing the sampling frequency to 1200 SPS (400 Hz for each geophone multiplied by 3 geophones = 1200 Hz).

To solder the capacitor you remove two squares of green paint with a small, sharp screwdriver. In this way one can solder and desolder the capacitors without heating the wire anchoring zone, and thus without risking to move them or to dissolve their insulating sheath. Even if you use larger capacitors should the same solder at this point and not on the wires that are delicate and can easily deteriorate.

The capacitors must be Ceramic, and better if a Surface Mount (SMD 0805) why they have best Features and cost just a few cents. The electrolytic capacitors or tantalum do not go well because they are biased. The polyester capacitors would be nice but are huge and expensive.

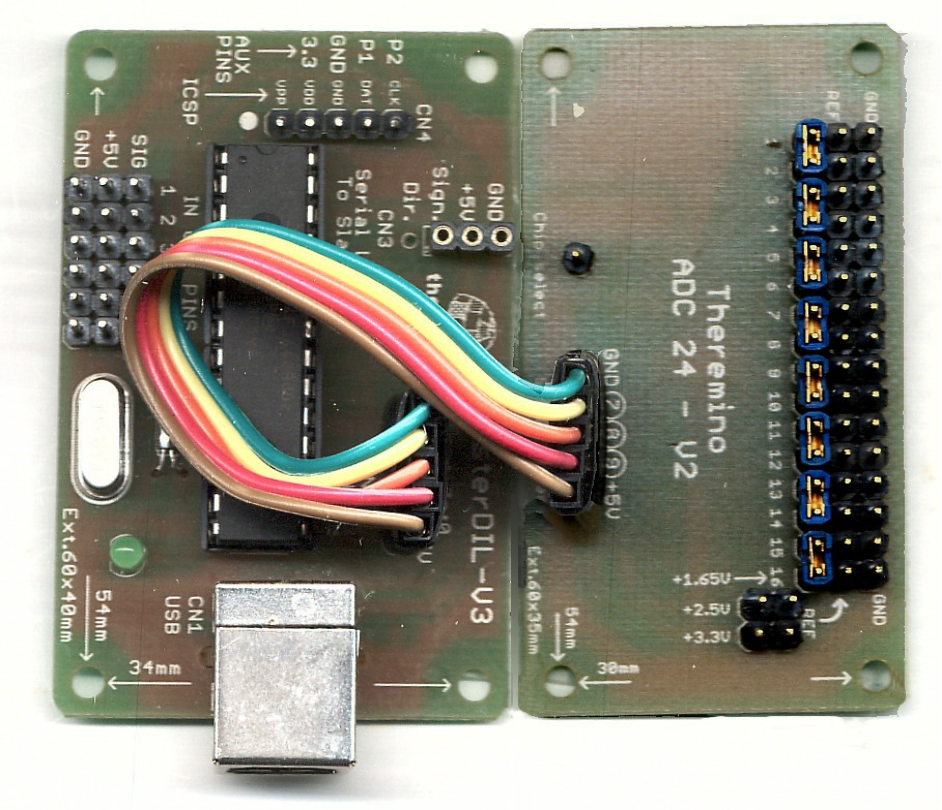
The cable shielding is also welded to the metal cylinder of the geophone to shield the inside winding. This welding must be done with skill, you have to shave a small area and pre-tinned with suitable tin and soldering iron. The area must be clean and deoxidized, so you can make a glossy and perfect soldering in seconds, not too much heat the carcass of the geophone. But you should also be sure to have heated enough, otherwise the solder may come off the first effort. If you have no experience with the soldering do to make this work to an expert (eg a good electronic equipment repairman).

For more information on connecting the geophones and other sensors, read the chapters “Connect geophones for micro tremors" and "Connect geophones with shielded cable" in the Adc24 instruction file, which you download from ***this page***.

Measure the Adc24 noise

There is nothing nell'Adc24 which may result in noise changes from one channel to another or from one device to another.

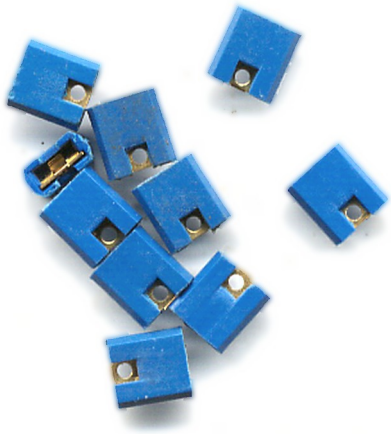
Then to measure the noise was more like a control. And the data supplied by the manufacturer have been fully confirmed by the measures. The noise values were virtually identical on all channels and all the devices we tested.



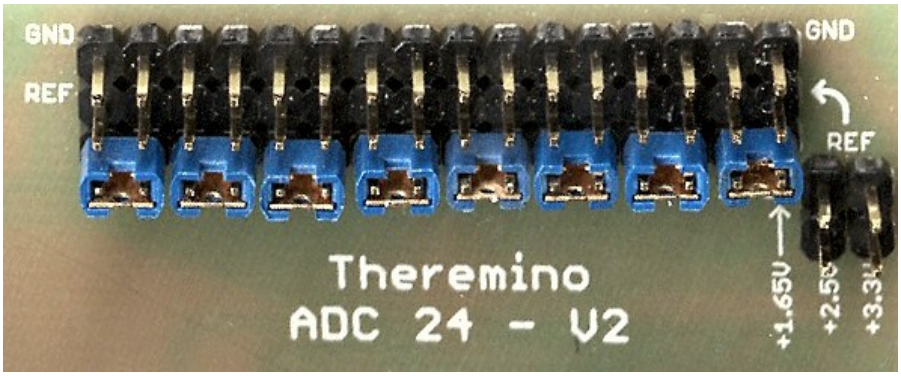
In this image we see the Adc24 equipped to measure the noise, with inputs closed with the jumpers.

Measure the Adc24 noise - Materials needed

To make the noise measurement of noise you need a Theremino Master and a dozen jumpers (those that were used for the Floppy and HardDisk selections).



The jumpers are positioned horizontally in order to close the inputs (1, 3, 5 ...) to their corresponding bias Pin (2, 4, 6 ...), as shown in the following image.



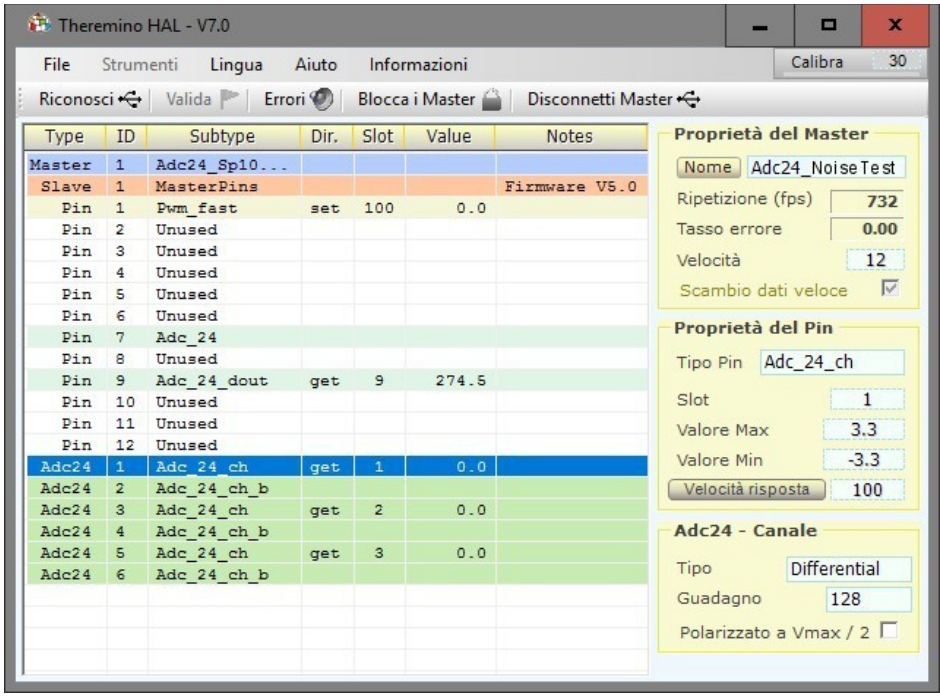
In place of the jumpers, you could connect shielded or simply twisted cables.

The cables may be connected to the geophones or shorted to the end.

This way you will be able to make comparisons between the Adc24 noise and the geophones signals, and also the shielded and unshielded cables signals.

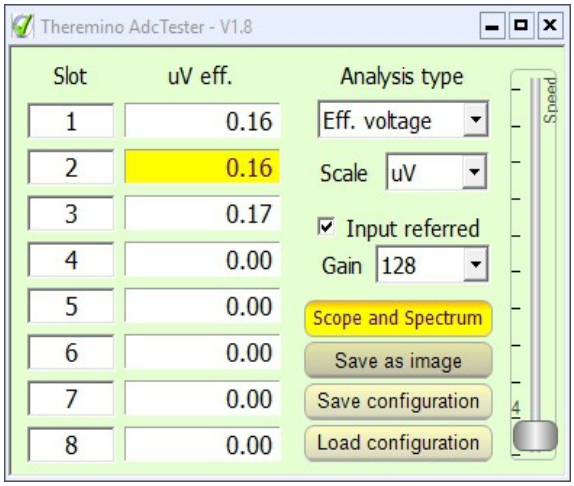
Measure the Adc24 noise - Images

The easiest way to prepare the applications is to use the ready configuration files.



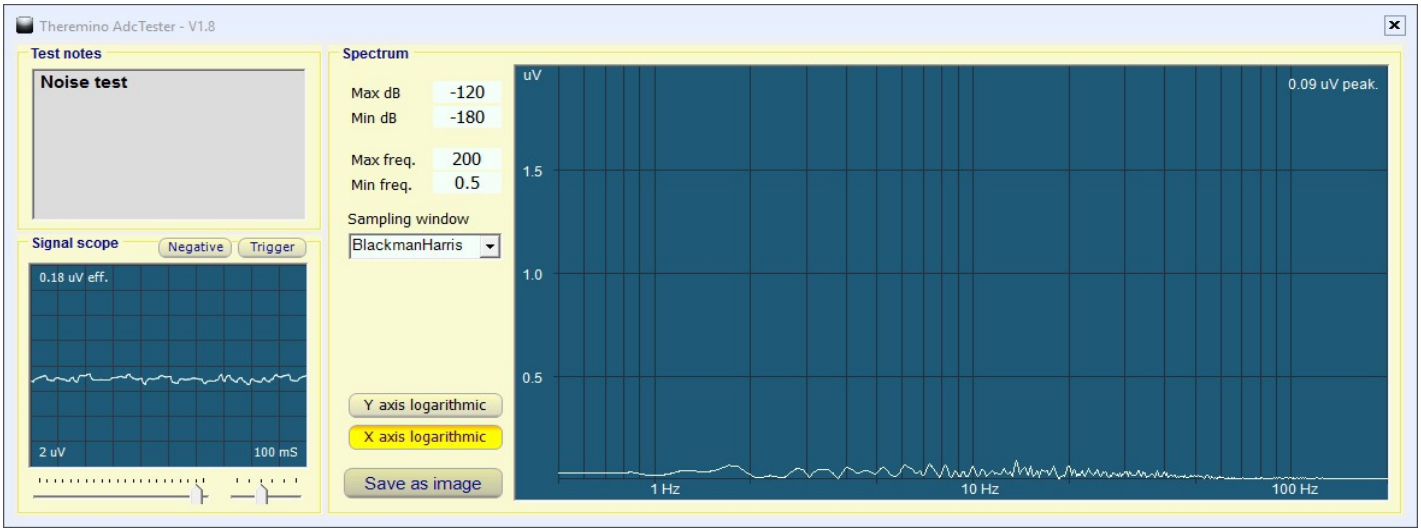
On the HAL application, click on the box with the name (to the right of the "Name" button) and load the "Adc24_NoiseTest" file.

On the AdcTester application press the "Load configuration" button and load the "Adc24_NoiseTest" file.



In these pictures you see should look like the applications.

Anyone wishing to control the parameters will find a list of all configuration parameters on the next page.



Measure the Adc24 noise - Manual configurations

On Theremino HAL the Pin 1 of the Master, that for the other measures is configured as "PwmFast", in this test is not needed, you can leave it as it is or configure it as "Unused".

On the Theremino HAL the Pin 7 of the Master must be configured with:

- Type = Adc_24
- Pin count = 6
- Samples/sec. = 600
- Filters = Max Speed

On the Theremino on HAL the first three odd Adc24 Pins (1, 3, 5), must be configured with:

- Type = Adc_24_ch
- Slot = 1, 2, 3
- Max value = 3.3
- Min value = -3.3
- Button "Quick response" = off (not orange)
- Speed = 100
- Type = Differential
- Gain = 128
- Polarized to Vmax / 2 = NO (white box)

On the Theremino HAL the first three even Pins of Adc24 (2, 4, 6), must be configured with:

- Type = Adc_24_ch_b
- Type = Differential
- Gain = 128
- Polarized to Vmax / 2 = YES (box with black mark)

The Theremino AdcTester be configured with:

- Analysis type = Eff. voltage
- Scale = uV
- Input Referred = YES (box with black mark)
- Gain = 128
- Scope and Spectrum = YES (lit yellow box)

The "Signal Scope" panel be configured with:

- Negative = Disabled (not of orange color)
- Trigger = Disabled (not of orange color)
- left cursor = 2 uV (penultimate notch on the right)
- right cursor = 100 mS (third notch from left)

The "Spectrum" panel be configured with:

- Max dB = -120
- Min = -180 dB
- Max freq. = 200
- Min freq. = 0.5
- Sampling window = NuttallNarrow
- Y axis = logaritmic disabled (not of orange color)
- X axis = logaritmic enabled (orange color)

Measure the Adc 24 gain

There is nothing in the Adc24 which may result in different gains on the various channels. The input circuits, the programmable amplifier and the ADC are switched in sequence on the active channels.

Then measure the channel gain was more like a control. And the theory was fully confirmed by the measures which, although with a very simple measurement hardware, have given gain values virtually identical on all the channels.

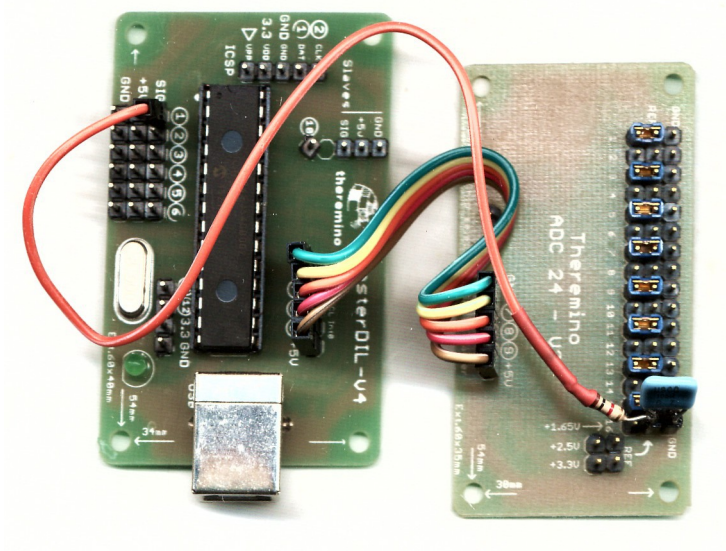
The gain differences (measuring very carefully, idle speed and scale in millivolts) were around one part in ten thousand (+/-0.01%) and are definitely attributable to the noise and the instability of the measures.

How do I gain far

To this test we transform the Pwm signal into a variable voltage with a very simple low-pass filter (a resistor 1k and a capacitor 1 uF). With such a simple filter residues PWM limit the dynamic to little more than 40 dB (in the spectrum analysis). We will also have limitations in frequency to use. The best results are obtained with a frequency of 5 Hz.

The frequency of "5 Hz" and the "Square" waveform allow maximum precision in measuring the gain. With these settings we can appreciate differences of less than one part in a thousand. If you used a sinewave or frequencies greater than 5 Hz, the aliasing effects make the measures most unstable. Instead frequencies lower than 5 Hz would exceed the length of the AdcTester receive buffer and also in this case the measures would become unstable and inaccurate.

It is not necessary to measure the gain at different frequencies. Once it is shown that the gain is equal for all channels, then it will surely also at higher and lower frequencies of 5 Hz, and in the whole field of the measures of our interest, that is, from 0.1 Hz to 250 Hz.



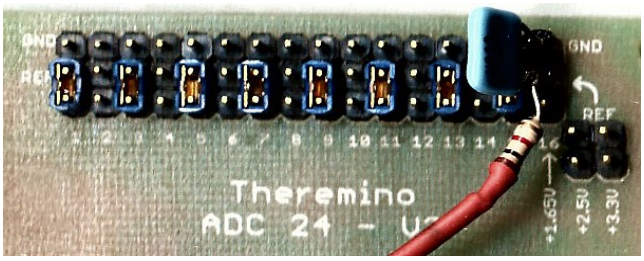
In this image we see the Adc24 prepared to measure the inputs gain.

Measure the Adc24 gain - Necessary material

To make measurements serve a Theremino Master and some readily available components.

Throughout they serve ten jumpers (those that were used for the Floppy and HardDisk selections).

The jumpers are positioned vertically, for connecting the inputs (1, 3, 5, 7, 9, 11, 13, 15) to the central bar (REF), as shown in the following image. attention that there must be no jumpers on connectors 1.65V, 2.5V and 3.3V.



In the central bar (REF) it is injected the test signal, with the adapter visible in this image.

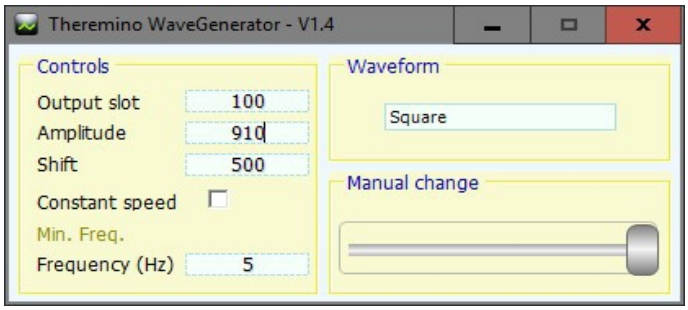
The adapter is connected with the single wire to Pin 1 signal of the Master. The connector with the capacitor and resistor is connected to Pin 16 of Theremino Adc24. The side of the resistance to the central pole "REF" and the side without resistance to the pole near the edge of the plate, marked "GND".

This adapter is a simple low-pass filter composed of a 1 kohm resistor (1/4 or 1/8 of a watt) and a 1 uF capacitor of any type. If the capacitor is electrolytic remember to connect the negative side to the ground (GND), that is the opposite side of the resistor.

Measure the Adc24 gain - Set the wave generator

The Wave Generator is located in the same "Theremino_AdcTester.exe" folder and should already be set by appropriate parameters for this test:

- OutputSlot = 100
- Amplitude = 910
- Shift = 500
- Constant speed = disabled
- Frequency = 5 Hz
- Waveform = Square



With the amplitude value 910, you should get about 3 V pp, that is 3000 millivolts.

With the “Scale = mV” on the AdcTester, you can appreciate three decimal digits, up to microVolt. If you lower the speed slider the first decimal place (hundreds of microVolt) should stand firm enough. And it is on these hundreds of microVolt you see the gain differences between channels.

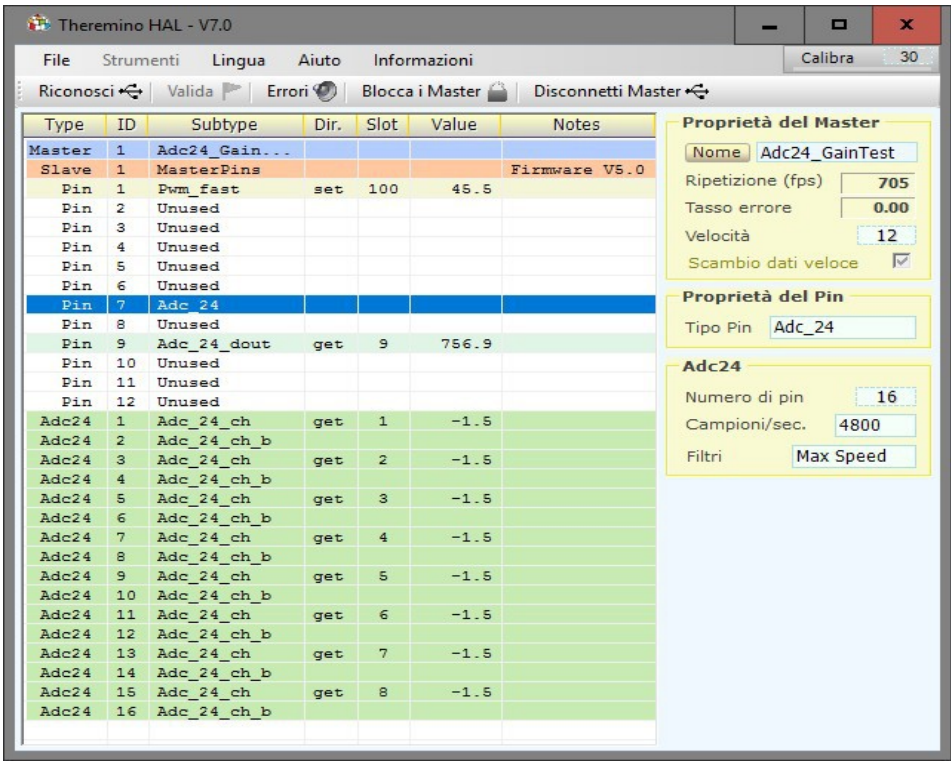
From one Adc24 to another variations occur up to +/- 1%, so to get exactly the value of 3 volts, you should change this value from 901 to 919.

Once calibrated the voltage to 3 volts you should slowly lower the cursor to stabilize the measures and gain differences between channels should be very small. If you measure correctly (raising the cursor to go to the maximum value quickly and then lowering it slowly, to stabilize the figures), you should obtain differences around one part in ten thousand.

It 'also possible to check the linearity of the system, setting the "Amplitude" to exactly one third of what gave 3 volts, and check that the measured values become 1 Volt. Even in this case to make good measures you have to lift the slider, to quickly bring the values close to the final value, and then lower the slider slowly, to stabilize the figures.

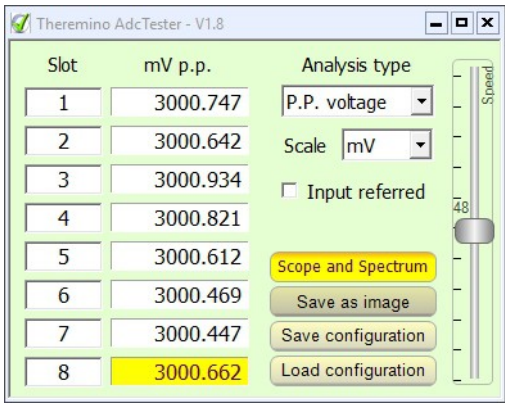
Measure the Adc24 gain - Images

The easiest way to set the applications is to use the ready configuration files.



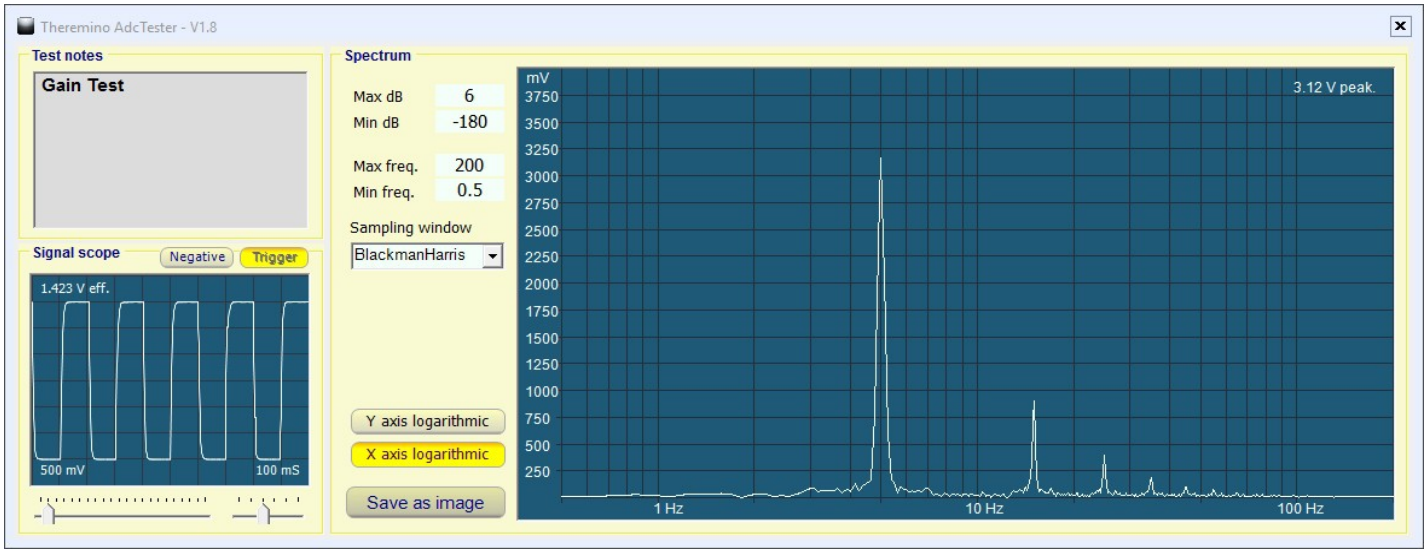
On the HAL application, click on the box with the name (to the right of the "Name" button) and load the "Adc24_NoiseTest" file.

On the application AdcTester press the "Load configuration" button and load the "Adc24_NoiseTest" file.



In these pictures you see how should look the applications. Note that all channels give similar values.

Anyone wishing to control the parameters will find a list of all configuration parameters on the next page.



Measure the Adc24 gain - Manual configurations

Launch the Theremino_WaveGenerator and configure it with:
- Output Slot = 100
- Amplitude = 910
- Shift = 500
- Constant speed = NO (white box)
- Frequency (Hz) = 5
- Waveform = Square

On Theremino HAL the Master Pin 1 must be configured with:
- Type = PwmFast
- Slot = 100
- Max value = 1000
- Min value = 0
- Button "Quick response" = off (not orange)
- Speed = 100
- Frequency = 15000
- Cycle from 0 to 1000 = not matter
- Frequency from slot = NO (white box)
- Cycle from slot = YES (Box with black mark)

On Theremino HAL the Master Pin 7 must be configured with:
- Type = Adc_24
- Pin count = 16
- Samples / sec. = 4800
- Filters = Max Speed

On Theremino HAL the eight Adc24 odd Pins (1, 3, 5, 7, 9, 11, 13, 15), are configured with:
- Type = Adc_24_ch
- Slot = 1, 2, 3, 4, 5, 6, 7, 8
- Max value = 3.3
- Min value = -3.3
- Button "Quick response" = off (not orange)
- Speed = 100
- Type = Differential
- Gain = 1
- Polarized to Vmax / 2 = NO (white box)

On Theremino HAL the eight Adc24 even Pins (2, 4, 6, 8, 10, 12, 14, 16), are configured with:
- Type = Adc_24_ch_b
- Type = Differential
- Gain = 1
- Polarized Vmax / 2 = YES (box with black mark)

The Theremino AdcTester be configured with:
- Analysis type = PP voltage
- Scale = Volt
- Input Referred = NO (white box)
- Scope and Spectrum = YES (lit yellow box)

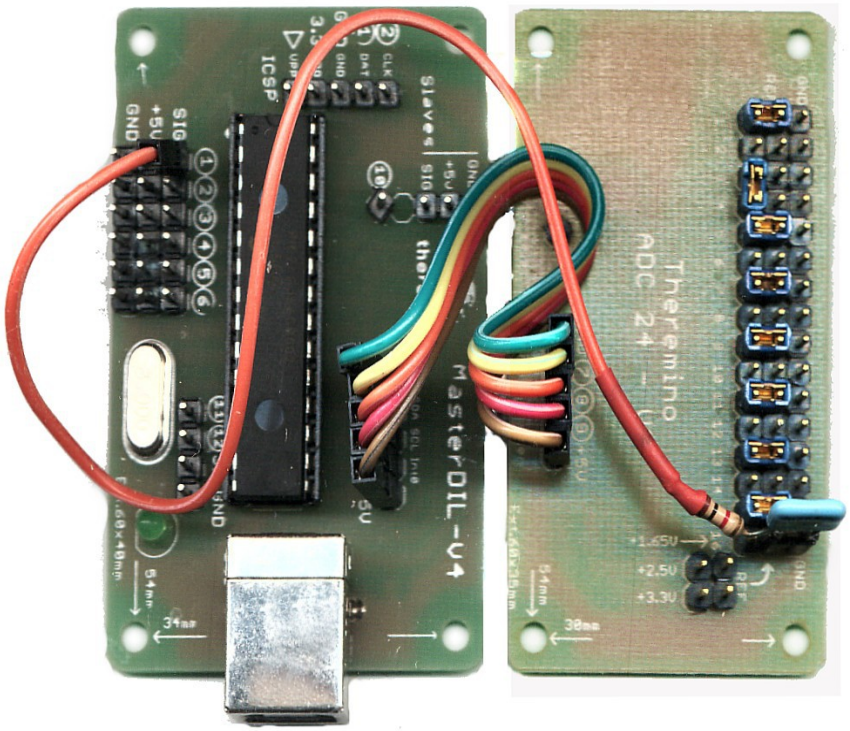
The "Signal Scope" panel is configured with:
- Negative = Disabled (not of orange color)
- Trigger = Enabled (orange color)
- Cursor left = 500 mV (second notch from the left)
- Cursor right = 100 mS (third from left notch)

The "Spectrum" panel is configured with:
- Max = 10 dB
- Min = -180 dB
- Max freq. = 200
- Min freq. = 0.5
- Sampling window = NuttallNarrow
- Y axis logaritmic = disabled (Not of orange color)
- X axis logaritmic = enabled (Orange color)

Measure the Adc24 intermodulation

We measured the intermodulation and found virtually zero for all samples tested.

No construction defect could give different results from these, so it is not necessary to test all the devices. Those who want to try them too, will find the configurations in the following pages.



In this image we see the Adc24 equipped to measure the intermodulation between channels.

The second input has an horizontal jumper, as in the noise measurements. While all other inputs is injected the strong signal coming from the PWM output, Pin 1 of the Master.

Measure the Adc24 intermodulation - Materials needed

To make measurements serve a Theremino Master and some readily available components.
Throughout they serve ten jumpers (those that were used for the Floppy an HardDisk selections).

The jumpers are placed vertically to connect the inputs to the central bar (REF) as shown in the following image. Attention that there must be no jumpers on connectors 1.65V, 2.5V and 3.3V.
The jumper of the second channel (Pin 3 and 4), is put in horizontal as in the noise measurements.

In the central bar (REF) it is injected the test signal, with the adapter visible in this image (the same adapter that is used for gain measurement).

The adapter is connected with the single wire to Pin 1 signal of the Master. The connector with the capacitor and resistor is connected to Pin 16 of Theremino Adc24. The side of the resistance to the central pole "REF" and the side without resistance to the pole near the edge of the plate, marked "GND".

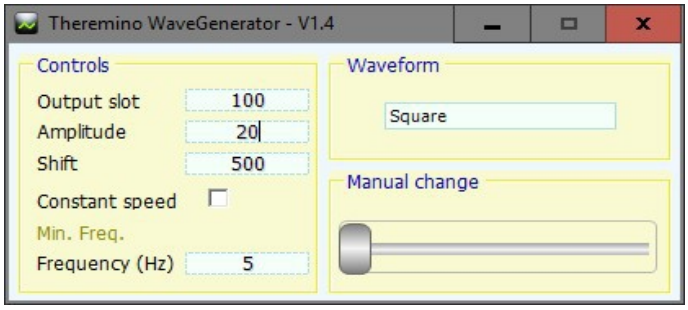
This adapter is a simple low-pass filter composed of a 1 kohm resistor (1/4 or 1/8 of a watt) and a 1 uF capacitor of any type. If the capacitor is electrolytic remember to connect the negative side to the ground (GND), that is the opposite side of the resistor.

Measure the Adc24 intermodulation - Set the WaveGenerator

The Wave Generator should already be set by appropriate parameters for this test:

- OutputSlot = 100
- Amplitude = 20 (but you can raise it up to 1000 to saturate the inputs)
- Shift = 500
- Constant speed = disabled
- Frequency = 5 Hz
- Waveform = Square

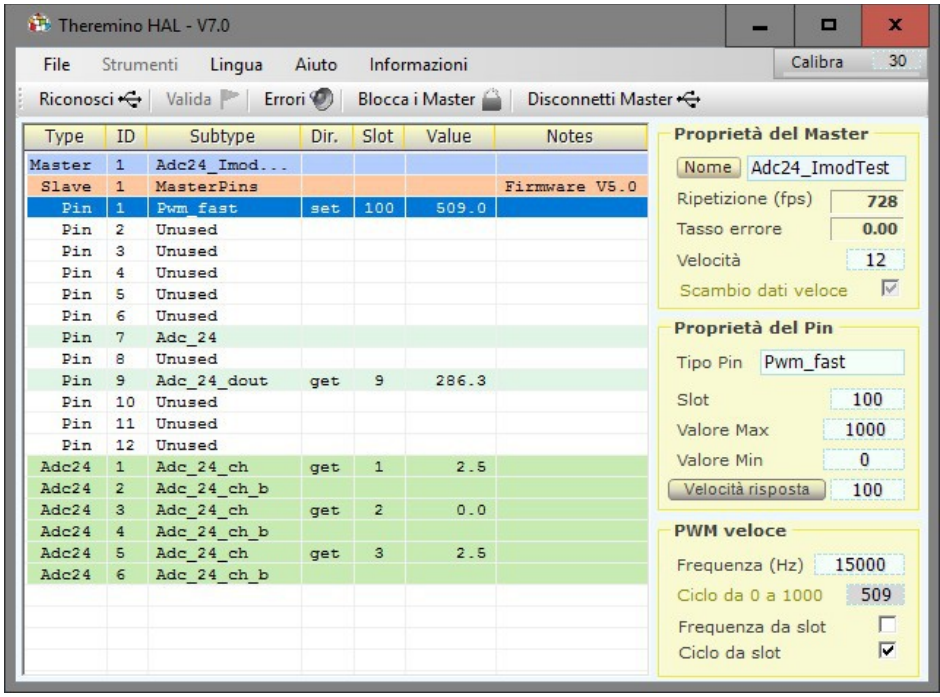
You can experiment with the amplitude, the value 910 that is used for the gain measures causes a strong saturation because in this test the amplified channels to 128. Instead the value 20 generates a very strong signal, near to the saturation limit.



Measure the Adc24 intermodulation - Images

The easiest way to prepare the applications is to use the ready configuration files read.

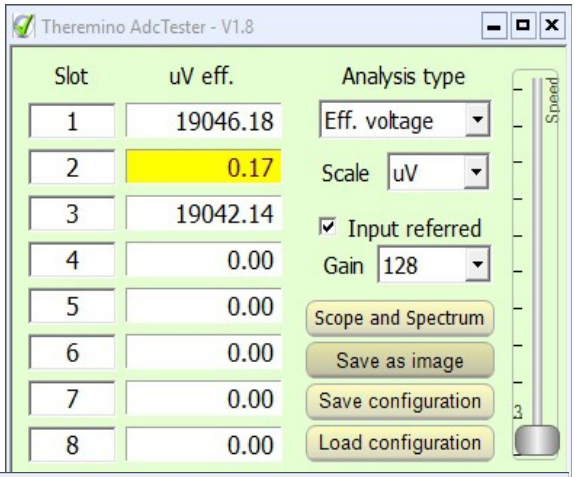
On the HAL application, click on the box with the name (to the right of the "Name" button) and load the "Adc24_ImodTest" file.

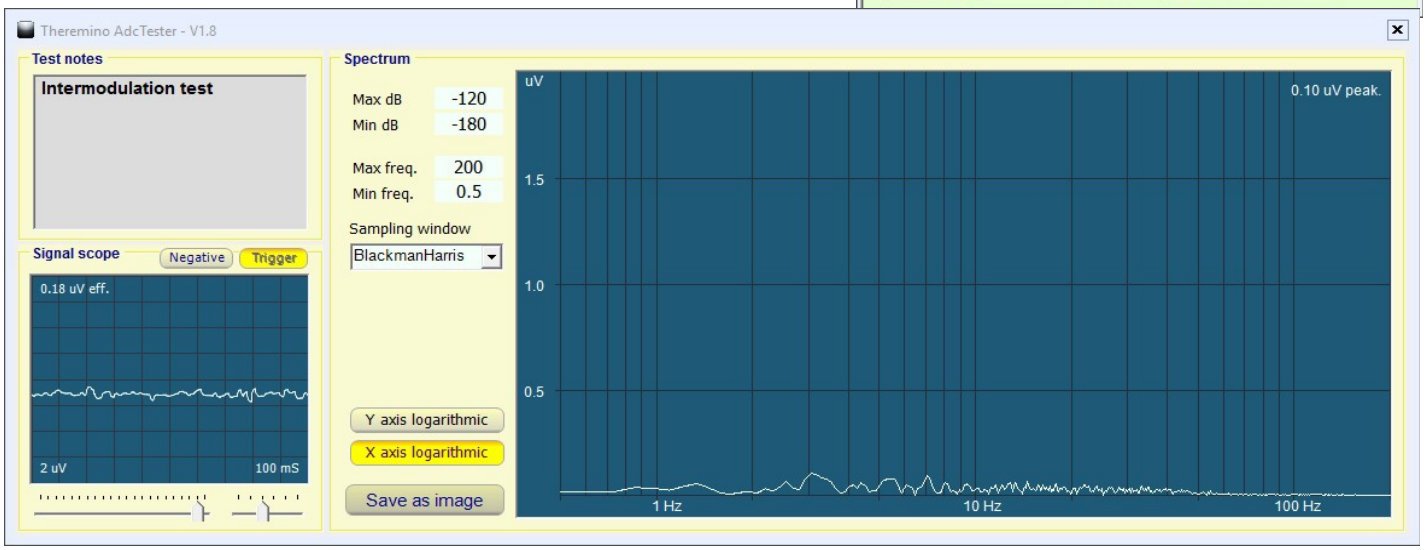


On the AdcTester application press the "Load configuration" button and load the "Adc24_ImodTest" file.

Check that the Slot 2 box it is selected (in yellow), to send its signal to the oscilloscope and spectrum analyzer.

In these pictures you see how should look like applications. Anyone wishing to control the parameters will find a list of all configuration parameters on the next page.





Measure the Adc24 intermodulation - Manual Configurations

Launch Theremino_WaveGenerator and configure it with:
- Output Slot = 100
- Amplitude = 20
- Shift = 500
- Constant speed = NO (white box)
- Frequency (Hz) = 5
- Waveform = Square

On Theremino HAL the Master Pin 1 must be configured with:
- Type = PwmFast
- Slot = 100
- Max value = 1000
- Min value = 0
- Button "Quick response" = off (not orange)
- Speed = 100
- Frequency = 15000
- Cycle from 0 to 1000 = not matter
- Frequency from slot = NO (white box)
- Cycle from slot = YES (box with black mark)

On Theremino HAL the Master Pin 7 must be configured with:
- Type = Adc_24
- Pin count = 6
- Samples/sec. = 600
- Filters = Max Speed

On Theremino HAL the first three odd Adc24 Pins (1, 3, 5), must be configured with:
- Type = Adc_24_ch
- Slot = 1, 2, 3
- Max value = 3.3
- Min value = -3.3
- Button "Quick response" = off (not orange)
- Speed = 100
- Type = Differential
- Gain = 128
- Polarized to Vmax / 2 = NO (white box)

On Theremino HAL the first three even Adc24 Pins(2, 4, 6), must be configured with:
- Type = Adc_24_ch_b
- Type = Differential
- Gain = 128
- Polarized to Vmax / 2 = YES (box with black mark)

The Theremino AdcTester be configured with:
- Analysis type = Eff. voltage
- Scale = uV
- Input Referred = YES (box with black mark)
- Gain = 128
- Scope and Spectrum = YES (lit yellow box)

The "Signal Scope" panel is configured with:
- Negative = Disabled (Not of orange color)
- Trigger = Disabled (Not of orange color)
- Cursor left = 2 uV (penultimate notch on the right)
- Cursor right = 100 mS (third from left notch)

The "Spectrum" panel is configured with:
- Max dB = -120
- Min = -180 dB
- Max freq. = 200
- Min freq. = 0.5
- Sampling window = NuttallNarrow
- Y axis = logaritmic disabled (Not of orange color)
- X axis = logaritmic enabled (Orange color)