

theremino
•the•real•modular•in-out•

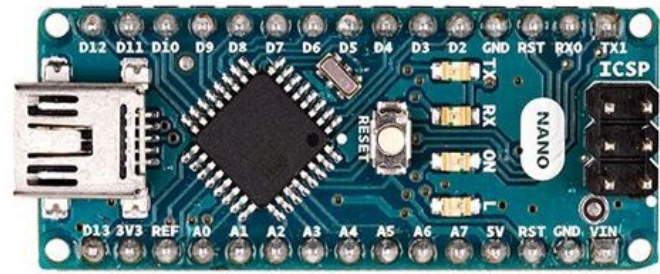
Theremino System

Theremino ArduHAL V2.6 Instructions

Principle of operation

You connect an Arduino Nano to the USB port.

You could also use other Arduino models, but read [This Page](#).



You use the Arduino IDE to program the Arduino with our firmware (as explained in [This Page](#)).

OR

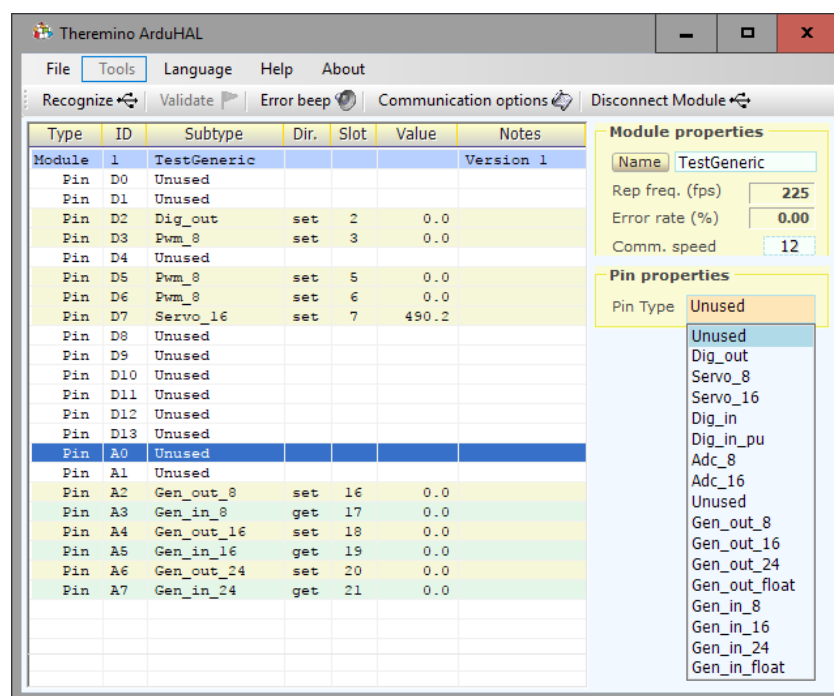
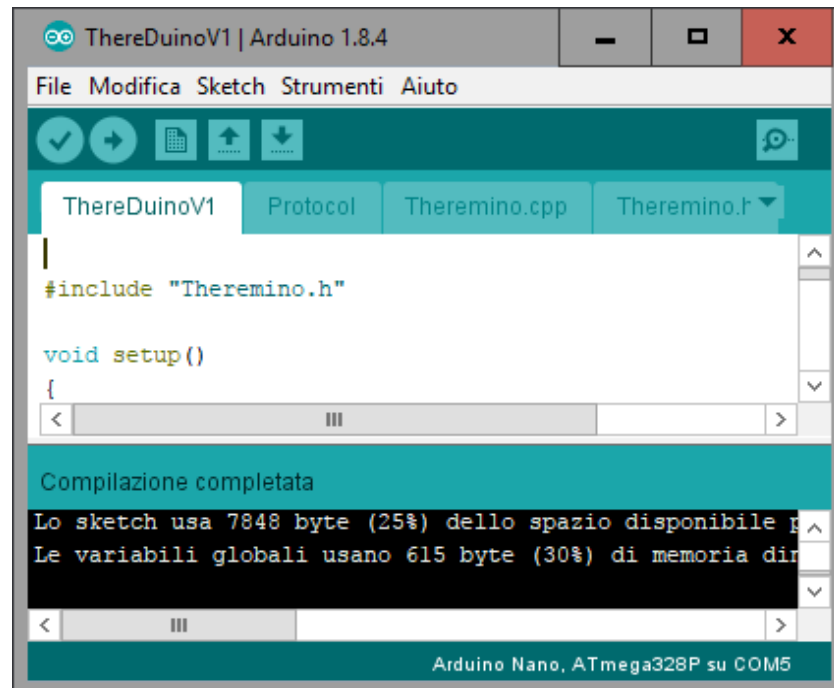
You could buy a pre-programmed Arduino Nano, on the [Store-ino](#) site, or from eBay.

With the pre-programmed modules you just connect the USB cable, and avoid to install the Arduino IDE and program the Arduino.

You launch the application [ArduHAL](#) and configure the IN-OUT Pins to read sensors, move motors, etc ..

You can use more than one hundred Theremino system applications, covering almost all fields, from scientific experiments to the music, to radioactivity, teaching... see [This Page](#).

All this works immediately without writing a single line of firmware or software.



Solve the most common problems

The Arduino module is not listed in the ArduHAL

If the module does not appears in the list check, in the “Communication options”, if the Comm Ports are OK.

Or, in the “Communication options”, set “Ports ALL” (meaning “all ports are valid”).

Check also if Baud Rates are the same as programmed in the firmware (usually 500000).

Can not communicate with the Arduino and can not program it

If the module contains a CH340, USB to serial type converter, it may be necessary to install the CH340 driver, as explained on [this page](#).

The communication is slow and with errors

If the module contains an FT232, USB to serial converter, the box indicating the errors will not mark zero and the communication will take place in a discontinuous way.

In these cases, set the "Polling" mode, as explained on [this page](#).

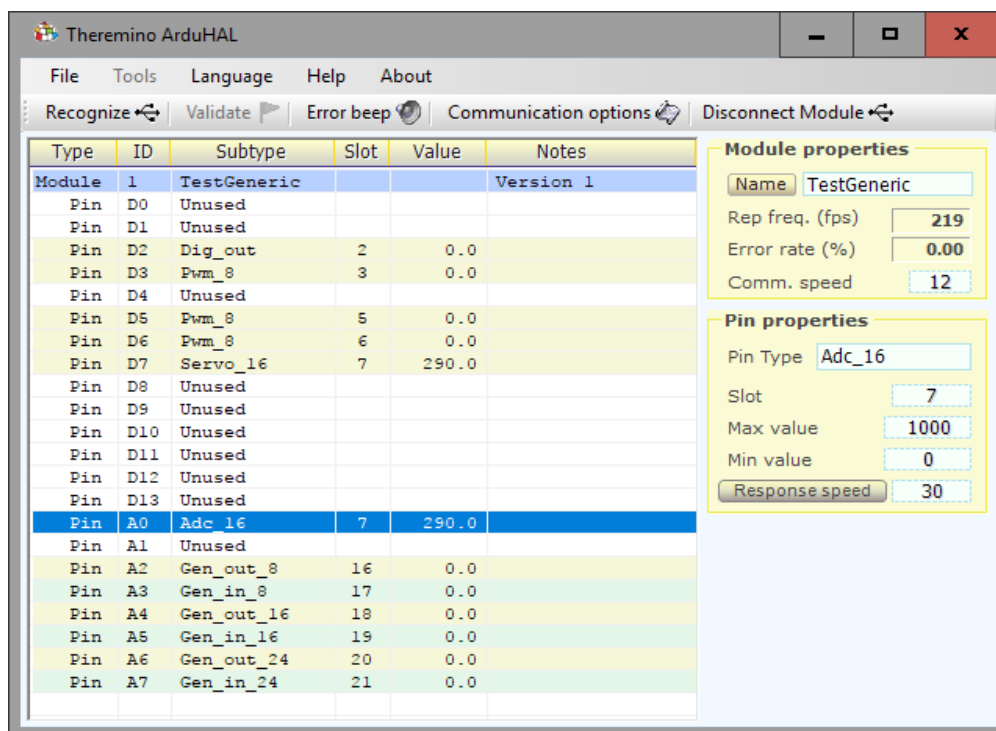
Read also the [FT232 chip page](#).

The communication (fps) is very slow

If the Sketch you program on Arduino contains pauses, delays, or slow calculations in the loop() function, the exchange rate (fps) may drop significantly.

In these cases the "Asynchronous mode" will increase the speed, as explained in [this page](#).

The ArduHAL application



Theremino ArduHAL with a module Arduino Nano connected

The application **ArduHAL** (Hardware Abstraction Layer), which is discharged from [This Page](#), it appears with a very simple interface, but performs complex operations, with algorithms that benefit from many years of research and development with the Master modules.

Theremino **ArduHAL** is the heart of communication with the hardware, can communicate with many Arduino modules simultaneously, he knows the serial communication protocol, knows all the most common types of input-output and allows you to easily configure them.

Without the HAL, to communicate with the Arduino hardware would be difficult and would require much time and labor. For each type of InOut, such as moving a motor or even light a LED, you should write the appropriate firmware.

In Theremino system there are also two other HAL, the first is simply called HAL and communicates via USB with modules Master, the second is called NetHAL and communicates via WiFi, network and Internet with the NetModules. In this document sometimes they will be referred generically as HAL to indicate all three applications.

If you use hardware modules then the HAL is indispensable and must remain on, you can minimize it, but must remain in operation.

If you do not use hardware then the HAL is not necessary, the theremino system applications of can communicate with each other, through the slot, even without HAL.

When you add or subtract modules, Some red lines warn that the configuration has changed. With the "Valid" button you choose to lose your old configuration and adapt existing hardware.

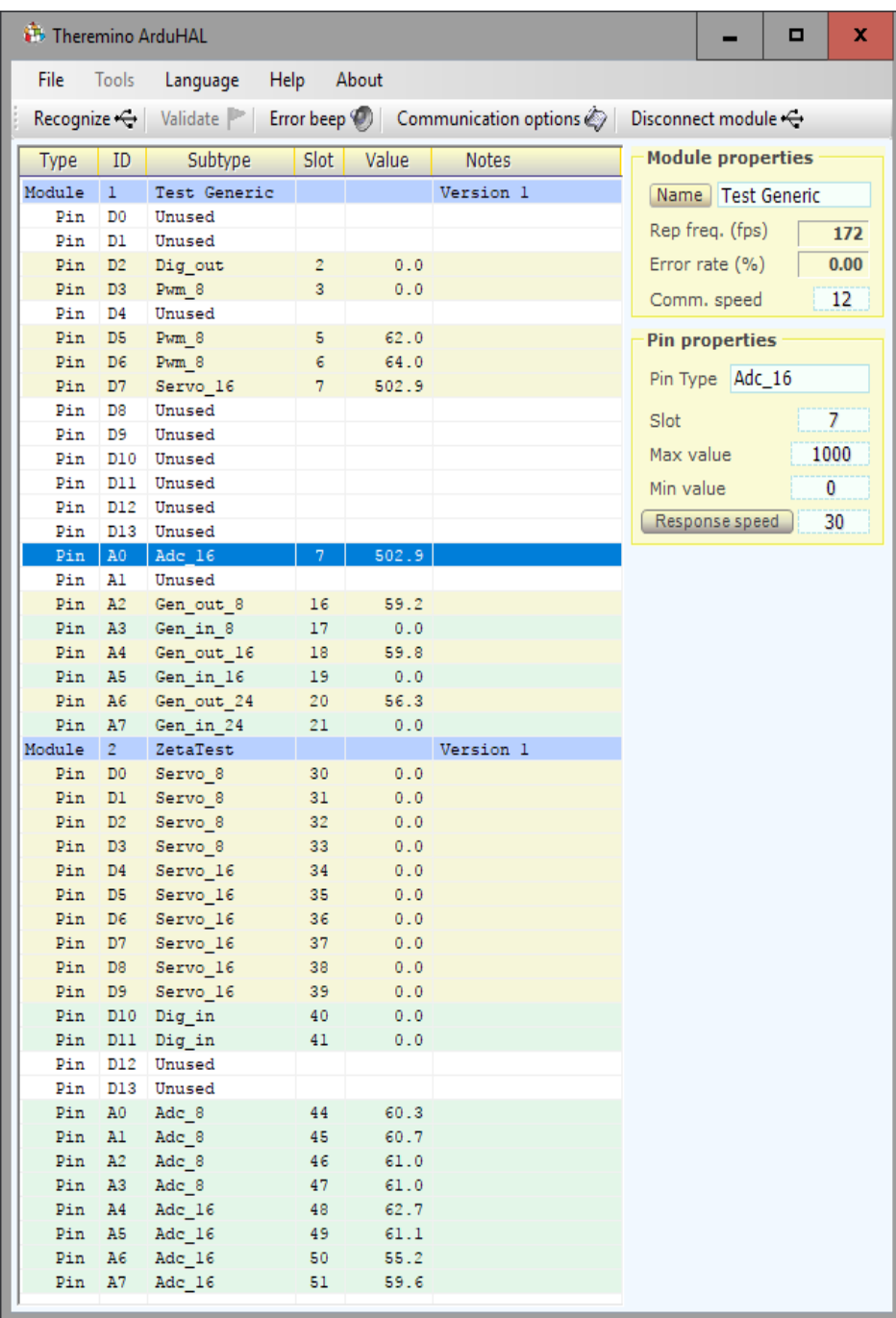
Connecting multiple Arduino modules

The application Theremino ArduHAL can communicate with any number of Arduino modules.

The Pin of all modules are read and written all at once and at the maximum speed from any Arduino. In other words, a slow Arduino does not cause a slowing of communication with others.

In the module list they will be presented in alphabetical order. So the list looks the same, even if you exchange the USB ports.

Theremino ArduHAL connected to two Arduino Nano modules (44 Pins in total)



The screenshot shows the Theremino ArduHAL application window. The main table lists two modules: "Test Generic" and "ZetaTest". The "Test Generic" module is connected to pins D0-D13 and A0-A7. The "ZetaTest" module is connected to pins D0-D13 and A0-A7. The "Module properties" panel shows the name "Test Generic", Rep freq. (fps) 172, Error rate (%) 0.00, and Comm. speed 12. The "Pin properties" panel shows the pin type "Adc_16", Slot 7, Max value 1000, Min value 0, and Response speed 30.

Type	ID	Subtype	Slot	Value	Notes
Module	1	Test Generic			Version 1
Pin	D0	Unused			
Pin	D1	Unused			
Pin	D2	Dig_out	2	0.0	
Pin	D3	Pwm_8	3	0.0	
Pin	D4	Unused			
Pin	D5	Pwm_8	5	62.0	
Pin	D6	Pwm_8	6	64.0	
Pin	D7	Servo_16	7	502.9	
Pin	D8	Unused			
Pin	D9	Unused			
Pin	D10	Unused			
Pin	D11	Unused			
Pin	D12	Unused			
Pin	D13	Unused			
Pin	A0	Adc_16	7	502.9	
Pin	A1	Unused			
Pin	A2	Gen_out_8	16	59.2	
Pin	A3	Gen_in_8	17	0.0	
Pin	A4	Gen_out_16	18	59.8	
Pin	A5	Gen_in_16	19	0.0	
Pin	A6	Gen_out_24	20	56.3	
Pin	A7	Gen_in_24	21	0.0	
Module	2	ZetaTest			Version 1
Pin	D0	Servo_8	30	0.0	
Pin	D1	Servo_8	31	0.0	
Pin	D2	Servo_8	32	0.0	
Pin	D3	Servo_8	33	0.0	
Pin	D4	Servo_16	34	0.0	
Pin	D5	Servo_16	35	0.0	
Pin	D6	Servo_16	36	0.0	
Pin	D7	Servo_16	37	0.0	
Pin	D8	Servo_16	38	0.0	
Pin	D9	Servo_16	39	0.0	
Pin	D10	Dig_in	40	0.0	
Pin	D11	Dig_in	41	0.0	
Pin	D12	Unused			
Pin	D13	Unused			
Pin	A0	Adc_8	44	60.3	
Pin	A1	Adc_8	45	60.7	
Pin	A2	Adc_8	46	61.0	
Pin	A3	Adc_8	47	61.0	
Pin	A4	Adc_16	48	62.7	
Pin	A5	Adc_16	49	61.1	
Pin	A6	Adc_16	50	55.2	
Pin	A7	Adc_16	51	59.6	

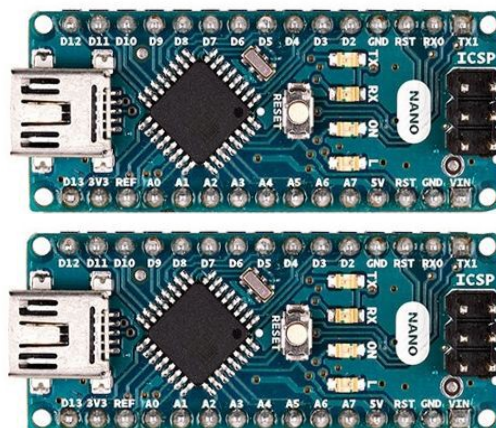
In this example we connected the two Arduino modules via a single USB cable. The cable goes to a USB HUB which provides four ports and the two Arduino were connected to two of these ports.

Any number of modules may be connected with any of the HUB configuration and USB ports.

You can use long USB cables up to a dozen meters, because we use a slow communication (with respect to the capacity of the USB).

The two modules were given the names "Test Generic" and "ZetaTest"

The names are stored in the Arduino themselves, to recognize them even if you exchange the USB ports.



Arduino and Master modules comparison

Advantages

- ◆ With Arduino is possible to add sensors connected in I2C, SPI or serial. We have prepared the "generic" types to communicate with the PC. So you just write a few lines and import a library to read even the strangest sensors.
- ◆ Even those with little programming knowledge can add some simple function. Instead modify the firmware of our Master is almost impossible. Not even an expert could do it, would take too long and it would not be worth.
- ◆ With Arduino you can program small operations to be performed quickly, for example, turn high an output and lower it after a time of a few microseconds. These same operations are not possible with a master module, because everything must be programmed on the PC and the minimum time allowed by the USB exchange is of a millisecond or two.
- ◆ An Arduino Nano costs less than half of a Master. It is also located less than three Euros on eBay.

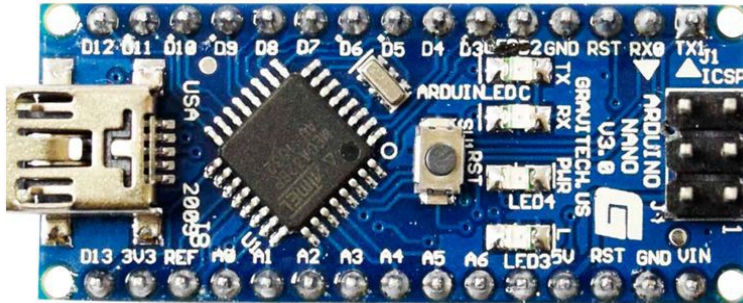
Disadvantages

- ◆ The simplified Arduino language (the Sketch) allows easy control of its firmware. But this leads to a great loss of performance. One example: the ADCs of our Master are read 16 times and is then averaged, while Arduino can read them only once, and is already a considerable load. To which the Adc Master give almost 14 bits (over-sampled), while those of Arduino only 10 bits.
- ◆ The communication speed with the PC is only a quarter of our Master even under the best conditions (about 250 exchanges per second against the normal 800 ... 900 of the Master).
- ◆ The pin can be configured with just a dozen kinds against almost thirty of the Master.
- ◆ Many types of Pin, such as capacitive keys, FastPwm and Stepper, are not feasible, the benefits are too scarce, better to use a Master.
- ◆ Nothing CapSensor and then nothing Theremin (musical instrument) with the features we're used to.
- ◆ The Adc24 is not connectable. We have not tried, but we know from experience that the SPI communication with the Adc24 module requires timings difficult to obtain. We did it on our Master, because we have all the possibilities given by a very powerful processor. And to do that we had to build a very complex set of Ping-Pong mechanism between two interrupts. Things like this are virtually impossible on Arduino (or at least we do not have the slightest idea of how to do it).

ATTENTION: You have to study well what you write in the loop Arduino, because any delay is reflected in the rate of exchange with the PC. Just one break of 100 mS to degrade the exchange rate from 200 per second to less than 10 (see [this page](#)).

The Arduino Nano modules

We recommend using the Nano that is the most similar to the Theremino Master modules.



The Arduino Nano is small and inexpensive, but has good performance and all our firmware has been developed for him. We tried other models, also more expensive, but they were worse.

Beware that there are two versions. The versions with the CH340 chip communicate faster. The chip CH340 is on the bottom side. To recognize it, see the next page.

The Nano with the CH340 chip normally reaches above 300 exchanges per second, while other models do not even reach 70. And some models (for example Zero, Leonardo, Micro, Esplora, Yun and others), do not have the “serial event”, and will function only selecting the “Async mode”, so more slowly.

Moreover many Arduino models have a different number of pins, and would require to modify the ArduHAL application.

We gladly leave to Arduino experts the pleasure of doing experiments with Arduino and to modify our firmware to make them work. But be careful, to do a good job you would have to modify the ArduHAL application too.



We should also buy the base with the screw connectors. The Arduino modules do not have the +5V and GND placed comfortably on Pins as our Master, so without the base it becomes difficult to connect the sensors and actuators.

With the base you can connect, for example, a Servo skinning their wires and screwing them. Not quite as comfortable with the Master but at least you can do it without welding.

The Arduino Nano has inputs and outputs that work between 0 and 5V. On the connectors there is a Pin with 5V and one with 3.3V to power sensors that need it.

The Arduino modules with the FTDI chip

There are three types of Arduino, depending on whether the serial USB converter is an Atmega (ATMEL), a CH340 (Quin Heng Technology), or an FT232 (FTDI).

Some Arduino Nano versions have the FT2232 chip, others the CH340 chip.

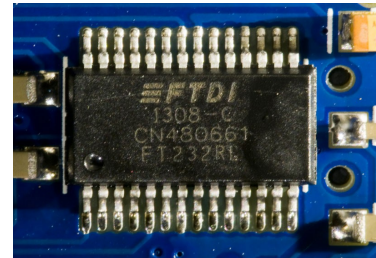
It is always better to use the versions with the CH340, because they go faster and create less problems.



Converter AtMega



Converter CH340



Converter FT232

The FT232 converter driver is not "Thread safe", ie if called by multithreaded applications it goes into "deadlock". The constructor is aware of the problem, in the Knowledge Base they call it "lockup", and they say that: *"some multithreaded applications can lock up during write communication with the devices"*. See the page www.ftdichip.com/Support/Knowledgebase

FTDI also suggests a solution, *"To prevent lockup with a multithreaded application..."*. Of course we have tried, but that does not solve the problem.

Therefore we had to add to the ArduHAL application the "Polling mode" option, which uses the driver in "polling", a method single-threaded, therefore slower, but with which you can run also the Arduino with the FT232 chip.

With the FT232 chip, the communication speed remains low. Using the "Polling mode" option, communication errors are eliminated, but a maximum of 70 fps is reached.

By changing the FT232 driver options you can increase this speed, not just at 350..400 as with the CH340 chips, but at least at 170..200.

- ◆ Check that the Arduino is connected to the USB
- ◆ Open the "Device Manager"
- ◆ In the Ports (COM and LPT) section, open "USB Serial Port"
- ◆ Open "Port Settings" and then "Advanced"
- ◆ Set "Latency time (msec)" with the value "1"

The FT232 chip can create additional problems, this time specifically generated [by the manufacturer \(FTDI\)](#). In some cases the driver will voluntarily cause errors (old drivers) or add messages in the serial data (recent drivers), to damage the chips of the competition.

In these cases there is no way to eliminate errors and there are no solutions, except to replace the drivers with a very difficult procedure. Anyone wishing to try can find information on the internet, [for example here](#).

Arduino modules with the CH340 chip

Some Arduino models communicate through a CH340 chip, which converts the data from USB to serial. This chip needs a special driver, which in some computers may be missing.

The CH340 chip is very good and provides a fast communication, but without the right driver you may not be able to communicate with the Arduino.

Symptoms

- The operating system signals an error when you connect the USB cable.
- By connecting the USB cable does not appear a new COM port.
- You can not program the Arduino
- The ArduHAL application does not show the Arduino module in the list

In these cases it solves the problem by installing the driver manually.

Download and install the Windows drivers

This is the official page of the manufacturer "Quin Heng Technology" for downloading the driver, for all types of CH340 (CH340G, CH340C, CH340B, CH340E, CH340T, CH340R, CH341A, CH341T, CH341H).

The driver is valid for operating systems Windows 10/8.1/8/7/VISTA/XP and Server 2016..2000/ME/98, both 32 and 64 bit, and certified by Microsoft Digital Signature.

http://www.wch.cn/download/CH341SER_EXE.html

To install the driver

- ◆ *Open the page by clicking on the link above*
- ◆ *Press the blue button "DOWNLOAD"*
- ◆ *Wait for the download to complete*
- ◆ *Click the CH341SER.EXE file*
- ◆ *Agree to the changes*
- ◆ *Press "Install"*

The firmware for Arduino

Our system opens new possibilities for those who want to use the Arduino as Input Output for PC.

With the, [over one hundred Theremino System applications](#), you can make measurements, automation, musical instruments, games and experiments of all kinds, both for teaching and for scientific laboratories.

Many have abandoned Arduino in a drawer after he realized that program it to communicate with the PC is not easy. Now these abandoned modules may be recovered.

For years we have waited for some Arduino expert prepare a communication protocol with our system. But in the end we had to learn the Arduino language and write it ourselves.

Firmware Features

Our firmware occupies only 25% of the program memory, and 25% of the dynamic memory of an Arduino Nano. So more than two-thirds dell'Arduino remain free to add other libraries and user firmware.

In this 25% we did stay all the serial communication protocol, as well as the management of the most common types of InOut, including servo motors and the library "Servo" that implements them.

Firmware Structure

We have implemented the firmware for the communication with the ArduHAL in a library.

A library can easily be loaded by accessing the "Sketch" menu and using the "include library" command and finally choosing "Add library from ZIP file" (which you download from [this page](#)).

Moreover, a library can be shared by many projects and therefore makes it easier to create new projects with parts of firmware written by the user.

Main File Structure "ThereDuinoV1.ino"

Our class is initialized and runs completely automatically, it just needs the following parts in the "ThereDuinoV1.ino" file:

- ◆ At the beginning of the file must be the line: `#include <Theremino.h>`
- ◆ In the "Setup" function the serial port is initialized. Normally the baud rate is 500,000, you can change it but it must be the same as you set in "CommOptions", accessible through the ArduHAL application.
- ◆ In the Arduino Sketch, the "Loop" function is completely empty and can be used by the user to write its firmware and possibly the functions "GenericRead" and "GenericWrite" to communicate numerical data with NetHAL (read the page of this document that explains Generic functions).
- ◆ Pay attention to what you write in the Arduino loop, because any delay is reflected in the exchange rate with the PC. If the "Async mode" is not enabled then a single pause of 100 mS is enough to degrade the exchange rate, from 300 per second to less than 10.

Write the firmware in the Arduino module

First, you must download the Arduino IDE from this page:

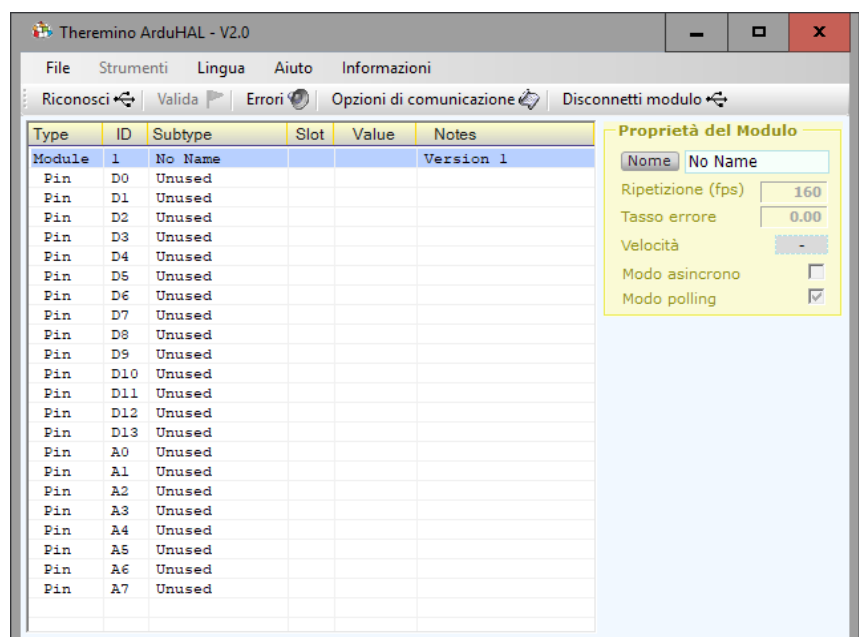
<https://www.arduino.cc/en/main/software>

Who has little experience can choose the "Windows Installer." Otherwise it is better to download the "Windows zip" version, which can then be unpacked in any folder and used on site without installing it. In addition, the zip version can easily be moved or copied from one PC to another. His only flaw is that you have to do everything manually and then knowing how to use ZIP, folders and shortcuts.

And here's the sequence to write the Arduino firmware

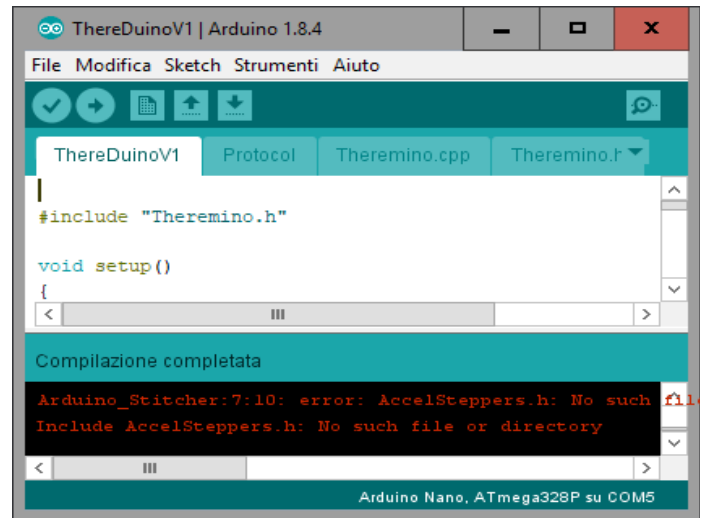
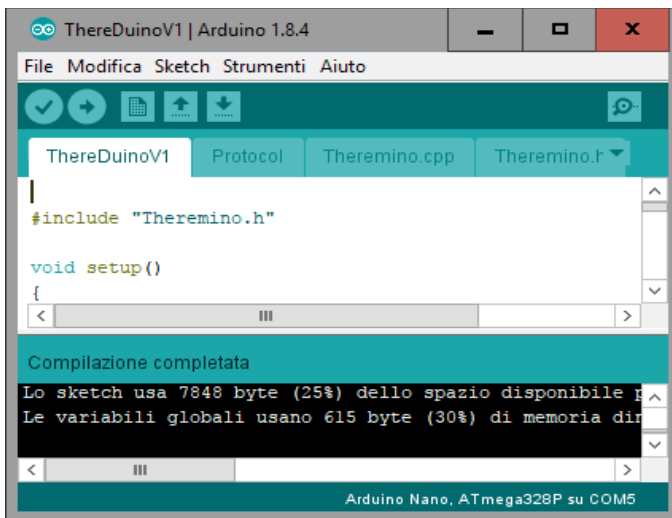
- ◆ Download the "ThereminoLibrary.zip" from [This Page](#).
- ◆ Start the Arduino IDE
- ◆ Open the "Sketch" menu, "#include library" and choose "Add library from ZIP file"
- ◆ In the dialog box that opens, locate the folder that contains "ThereminoLibrary.zip", select it and press "Open".
- ◆ Open the "File" menu, press "Open" and find the Theremino library (probably in "Documents/Arduino/Libraries").
- ◆ Open the "Tools" menu .
Select the module type (probably Arduino Nano),
Select the processor (probably ATmega328P)
Select the COM port. To figure out which is the right port, try unplugging and replugging the USB Arduino and each time open the "Tools / Port".
- ◆ Open the "Sketch" menu and click "Upload"
- ◆ If all went well, the green bar will grow up right and the Arduino is programmed.

Finally launch the ArduHAL application and must appear twenty-two "Unused" lines, as in this image.



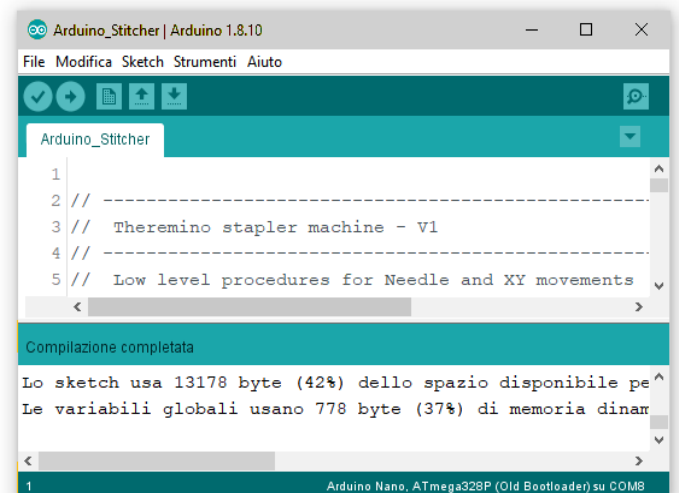
Modify the Arduino editor (IDE)

The messages of the Arduino editor are in dark white on black and it is a bit difficult to read them, then when there are errors the color becomes dark red on black, look at the two images below.



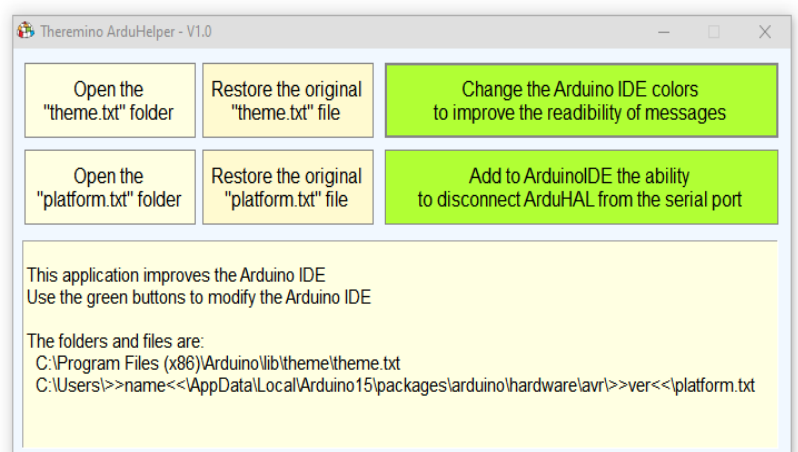
To change the colors of Arduino you would have to modify one of its files, quite difficult.

We have therefore written an application (ArduHelper) that modifies the colors and the result is what you see on the right.



The ArduHelper application can also add to the Arduino editor, the ability to inform ArduHAL that it is compiling.

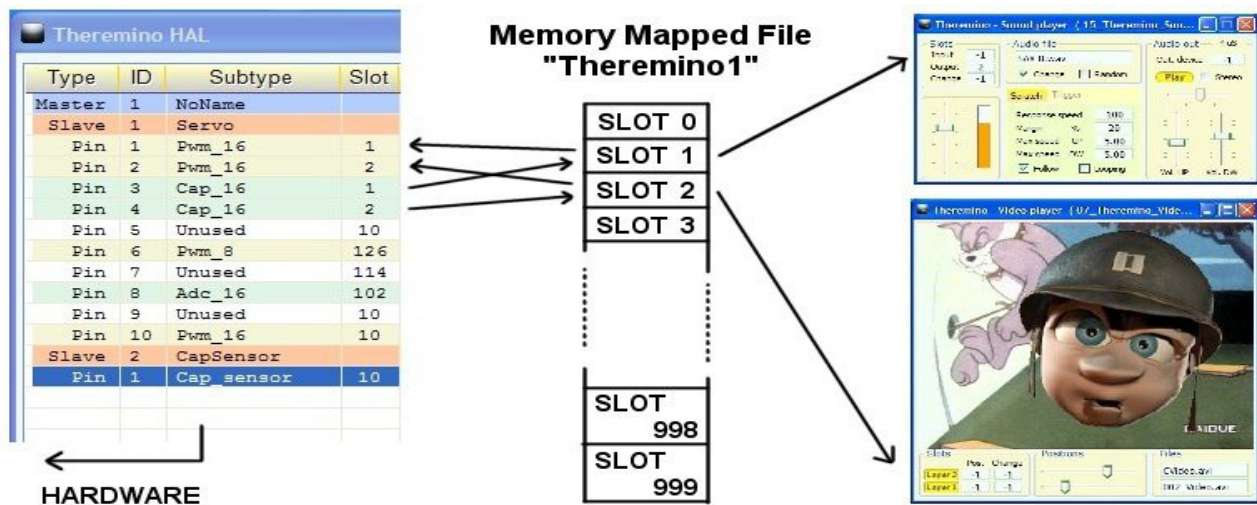
When ArduHAL receives the message "Disconnect" (see [this page](#)) it releases the serial port and waits for the port to become free, to reconnect (for a maximum of 25 seconds).



The "Theremino_ArduHelper" is downloaded from the same page of [Theremino_ArduHAL](#).

The "Slots"

The Theremino System Slots are identified by a number from 0 to 999 and are all part of a MemoryMappedFile called "Theremino1". Each Slot contains a "Float" number, which can be read or written by any module of the Theremino System.



In this picture, only HAL writes in the Slots, but in reality all the components of the system can both read and write in any of the Slots, even if already used by others.

Choosing the right Slot, you should be aware of two things:

- ◆ Ensure you do not use the same Slot by mistake, for two different functions.
- ◆ Avoid writing on the same Slot, with two or more components.

Input Pins, that are writing in the Slots, are highlighted in light green. If two or more input pins have the same Slot, then the HAL application warn with red lines and the text **SLOT CONFLICT**.

Many applications and Pins can read from the same Slot. But avoid configuring more than one Pin writing on the same Slot; doing so nothing is broken, but the results are unpredictable.

Sending multiple streams of data to the same Slot, all data are mixed and the last who writes wins. if you want to merge data in order, some rules are required.

Type	ID	Subtype	Slot	Value	Notes
Master	1	TestSlotCo...			
Slave	1	MasterPins			Firmware V5.0
Pin	1	Adc_16	1	105.3	
Pin	2	Adc_16	2	99.5	
Pin	3	Dig_in	4	0.0	SLOT CONFLICT
Pin	4	Dig_in	4	0.0	SLOT CONFLICT
Pin	5	Dig_in	5	0.0	
Pin	6	Dig_in	6	0.0	
Pin	7	Dig_in_pu	7	1000.0	
Pin	8	Unused			

To establish mathematics and logic rules between the Slots and to write complex behavioral algorithms, as well, we use Theremino Automation or Theremino_Script, or else any other programming language, such as C + +, CSharp, VBnet or VB6. Visual languages like MaxMSP, Processing, PureData, LabView and EyesWeb, can also be used. Plugins and examples for MaxMSP, are ready made here:

www.theremino.com/en/downloads/foundations

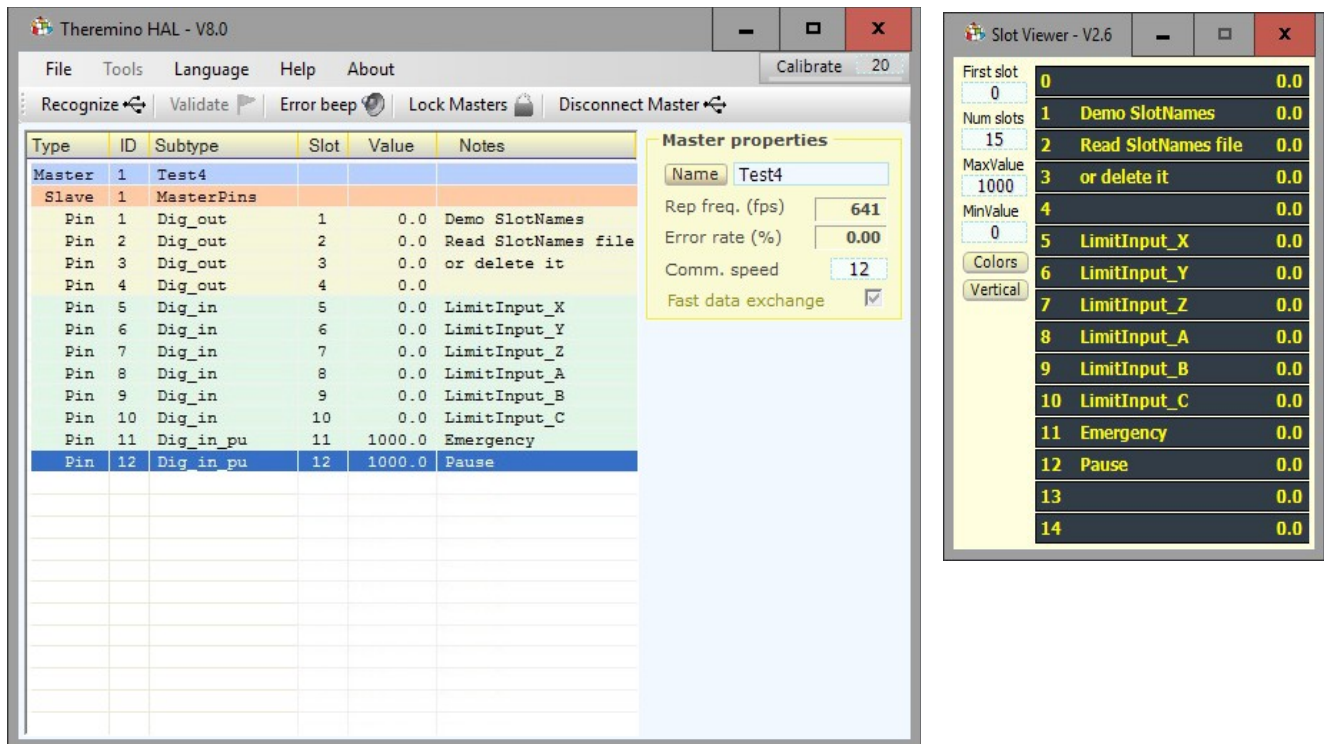
For more information about communication, please check this page:

www.theremino.com/en/technical/communications

www.theremino.com/en/technical/pin-types

The Slot names

All the HAL applications and even SlotViewer can view the names of the slot (or annotations or comments).



Important to note that the names are not related to physical Pins, but to the Slots.

The names are written in a file, that should be called "SlotNames.txt" and that must be in the same folder as "Theremino_ArduHAL.exe" folder" and "Theremino_SlotViewer.exe". If the file "SlotNames.txt"

If the file "SlotNames.txt" is not present then the comment field will remain empty.

To modify the Slot names you open the "File" menu, choose "Edit slot names file", and edit it with the default system editor (normally NotePad). Finally you save the file and it will be reloaded automatically.

The rules are simple and are shown in the sample file, located in the latest versions of HAL and SlotViewer.

Each line of the file begins with the Slot number, followed by a space and the text to be displayed. The line can also continue with a comment, that does not appear, preceded by a single quote.

If you want to use the same file of comments, for both HAL and SlotViewer, you have to keep the files "SlotNames.txt", "SlotViewer.exe" and "ArduHAL.exe", all in the same folder.

Slots for text commands

From early 2024, Theremino System applications and user-created applications can send commands in text form and receive responses from the HAL, using two **TextSlot** to communicate.

In the next few pages we will see that one also exists **Slots** to send numeric commands, but with text commands you can do many more things, practically everything you could do with the mouse and keyboard on the HAL interface.

When to use Number Slots instead of TextSlots

There is only one case in which it is preferable to use the Numeric Command Slot.

When you want to know the number of Masters (i.e. hardware modules) that have been recognized and are active, with numeric Slots you just need to read the value of the Slot and this happens in a few microseconds, whereas if we did it with TextSlots it would be necessary to send a command to ask for the value and then wait for the response. And this would take tens of milliseconds.

For this reason and also to make it easier for those who are already using them in their applications, we have also kept the numeric slot commands active.

Numbers to use for TextSlots

The **TextSlot** they have numbers from 0 to 999 like number slots but they are two different things. Even if the same number is used **TextSlot** and **numeric Slots** they do not interfere with each other.

If not set differently, the **TextSlot zero** for the commands and the **TextSlot one** for the answers.

Use other Slots instead of TextSlots zero and one

Usually the command TextSlots are zero and one, but it may happen that you want to use multiple independent applications on the same PC. In these cases each application would reside in separate folders along with its HAL and access its Master modules using the "Lock Master" command. In these cases, a different command slot can be assigned to each HAL. For the commands you can use any TextSlot (from 0 to 999) but be careful not to use it for anything else.

To assign numbers to the command slots, manually modify the last lines of the "Theremino_HAL_INI.txt" file. So to use, for example, TextSlots 300 and 301, you would write: **CommandTextSlot=300** and **ResponseTextSlot= 301**.

Be careful not to delete the "=" signs. In case of errors, slots zero and one are used and the HAL rewrites the correct line in the INI file.

How to send commands

After sending a command, before sending another it is best to wait at least 50 or 100 ms to give applications time to perform writing and reading even in the worst cases.

To minimize this wait, you check the text in the CommandTextSlot and continue as soon as it is deleted from the HAL.

See the Automation example: **Demo Programs\SlotText Commands\Commands_to_HAL.txt**

Commands with TextSlots

In the next pages we will list all the usable commands but **only the HAL application recognizes them all.**

ArduHAL, IoTHAL, and NetHAL use only a portion of the commands, and many of the commands are only valid when the Pin types that use them are selected.

Commands ending in ON/OFF are enablements. Any value other than a zero or the word OFF is considered ON. Normally 1/0 or ON/OFF are used.

Both commands and their additional parameters can be written indifferently with uppercase or lowercase characters in any combination.

The command parameters, such as the names of the Masters, the types of Pins, the types of Filters and the types of Adc24 channels, are recognized only on the basis of their alphanumeric characters. For parameters, spaces and other signs do not matter. So for example "Dig_in_pu" could be written as "diginpu" or even "DIG-IN___PU" and would still be recognized and considered valid.

Top bar commands

- | | |
|--------------------------------------|---|
| ● Recognize | It has the same effect as the Recognize button. |
| ● Validate | Has the same effect as the Validate button. |
| ● ErrorBeep ON/OFF | Enable or disable the Error Beep button. |
| ● LockMasters ON/OFF | Enable or disable the Lock Masters button. |
| ● Disconnect | Disconnects the selected Master (module). |
| ● NoEdits ON/OFF | Enable or disable the NoEdits button. |
| ● Calibrated | Enable or disable the Calibrate button. |
| ● CalibrationValue N (1..100) | Numeric value for the "calibrate" box. |

Master Commands (or modules)

- | | |
|----------------------------------|---|
| ● SelectMaster N (note1) | Select the Master (if there are more than one). |
| ● LoadConfig XXX | Load the XXX configuration for the selected Master. |
| ● Speed N (1..12) | Communication speed for the selected Master. |
| ● FastDataExchange ON/OFF | Enable or disable FastExchange (only for Slave modules) |

(Note1)

The SelectMaster command is also recognized if you write SelectModule which may be more appropriate for Arduino and ESP32 modules.

Commands with TextSlots (part 2)

Select PINs

To select the Pin a text string is used although in many cases this string will simply contain numbers from 1 to 12.

But when using the Arduino and Esp32 modules, the Pins are not numbered in sequence, for example 22, 35, 28, 60 etc. and in some cases they are alphanumeric, for example A0, A1, A3, D0, D1, D3 etc. .

So in all cases instead of a number the name of the Pin is indicated as a text string.

Command to select PINs



SelectPin XXX

A text string is used for the Pin name

Numbering for the ADC24 and CAP-SENSOR pins

When using the Masters with the Theremino_HAL app. and connecting an Adc24 and/or one or more CapSensors, the pin numbering is different from what you might imagine.

The Master Pins range from 1 to 12.

Then the numbering continues indicating the Adc24 with 13, 14 and following.
(in this case they range from 13 to 28)

And also the CapSensors continue with the numbering.
(in this case are indicated with 29 and 30 but without Adc24 would be 13 and 14)

Type	ID	Subtype	Slot	Value	Notes
Master	1	Adc24AndCa...			
Slave	1	MasterPins			Firmware V5.0
Pin	1	Unused	← 1		
Pin	2	Unused			
Pin	3	Unused			
Pin	4	Unused			
Pin	5	Unused			
Pin	6	Unused			
Pin	7	Adc_24			
Pin	8	Adc_24_din			
Pin	9	Adc_24_dout	109	917.6	
Pin	10	Unused			
Pin	11	Unused			
Pin	12	Unused	← 12		
Adc24	1	Unused	← 13		
Adc24	2	Unused			
Adc24	3	Unused			
Adc24	4	Unused			
Adc24	5	Unused			
Adc24	6	Unused			
Adc24	7	Unused			
Adc24	8	Unused			
Adc24	9	Unused			
Adc24	10	Unused			
Adc24	11	Unused			
Adc24	12	Unused			
Adc24	13	Unused			
Adc24	14	Unused			
Adc24	15	Unused			
Adc24	16	Unused	← 28		
Slave	2	CapSensor			
Pin	1	Unused	← 29		
Slave	3	CapSensor			
Pin	1	Unused	← 30		

Commands with TextSlots (part 3)

Pin properties (Pin properties panel)

- **SetPinType XXX** Set the type for the currently selected Pin.
- **SetSlotNo(0..999)** Set the Slot for the selected Pin.
- **SetMaxValue N** Set MaxValue for the selected Pin.
- **SetMinValue N** Set MinValue for the selected Pin.
- **SetPinType XXX** Set the type for the selected Pin.
- **SetResponseSpeedButton ON/OFF** Enable or disable the ResponseSpeed button.
- **SetResponseSpeed N (1..100)** Sets the ResponseSpeed value.

Properties for PWM and SERVO Pins (PWM properties and SERVO properties panels)

- **MaxTime N** Set Max time for the selected Pin.
- **MinTime N** Set Min time for the selected Pin.
- **LogarithmicResponse ON/OFF** Enable or disable the Logarithmic response button.

Properties for STEPPER type Pins (Stepper properties panel)

- **MaxSpeed N** Set Max sp. (mm/min) for the selected Pin.
- **MaxAcc No** Set Max acc. (mm/sec/s) for the selected Pin.
- **StepsPerMm N** Set Min time for the selected Pin.
- **LinkedtoPrevious ON/OFF** Enable or disable the Linked to previous button.

Properties for PWM FAST type Pins (Pwm_Fast properties panel)

- **PwmFastFrequency N** Set the PWM frequency.
- **PwmFastDutyCycle N(0..1000)** Set the Duty Cycle.
- **FrequencyFromSlot ON/OFF** Enable or disable frequency control from the Slot.
- **DutyCycleFromSlot ON/OFF** Enable or disable duty cycle control from the Slot.

Properties for CAP type Pins(Touch properties panel)

- **MinVariation N (-1000..+500)** Set the minimum variation.
- **ProportionalArea N (-500..+1000)** Set the proportional area.

Properties for COUNTER and PERIOD type Pins(Freq properties panel)

- **ConvertToFrequency ON/OFF** Enable or disable frequency conversion.
- **MaxFrequency N** Set the maximum frequency.
- **MinFrequency N** Set the minimum frequency.

Commands with TextSlots (part 4)

Properties of CapSensor and Usound type Pins (CapSensor and Usound properties panels)

- **MaxDist N** (50..9999) Set the maximum distance in mm.
- **MinDist N** (0..5000) Set the minimum distance in mm.
- **Area N** (0..9999) Set the area in square mm (only for CapSensors).
- **RemoveErrors ON/OFF** Enable or disable error checking for the Usound type

Properties of Adc24 type Pins (Adc24 properties panel)

- **NumberOfPins N** (0..16) Set the PIN number (only for Masters, not ESP32).
- **SamplesSec N** (10..19200) Set the sampling rate.
- **Filter XXX** Set the filter type (MaxSpeed, Fast, Medium etc..)

Properties of Adc24_ch and Adc24_cn_b type Pins (Adc24_channel properties panel)

- **Type XXX** Set the type (Differential, Pseudo Diff, Single ended).
- **Gain N** Set the gain (0, 2, 4, 8, 16, 32, 64, 128)
- **Biased ON/OFF** Enable or disable 1.65 volt bias.

VALUE REQUESTS

- **GetMasterName (note 1)** Request for the name of the selected Master (module).
- **GetFPS** Request for the current communication frequency.
- **GetPinType** Type request for the selected Pin.

ANSWERS

- **OK** The command was executed successfully.
- **Error text** It also includes the command that generated the error.
- **Required parameter** The value that was requested with one of the **GET** commands.

(Note 1)

The GetMasterName command is recognized even if you write GetModuleName which might be more appropriate for Arduino and ESP32 modules.

Commands with the numerical Slots

The Theremino System applications, or other applications created by users, can communicate with the HAL, sending commands or receiving data, using a numerical Slot to communicate.

For example an applications may change the parameters of all the Pins, rewriting the configuration file, and then sending the command "Recognize". Or an application could verify how many Masters are really connected, sending the "Recognize" command, and then reading their number from the Command Slot. Or a musical application could calibrate the CapSensor modules or the CapKeys, sending the "Calibrate" command (actually unimplemented in the Arduino modules).

Using other Slots in place of the Slot zero.

Normally the Command Slot is zero, but may happen that you want to use multiple independent applications on the same PC. In these cases, each application would reside in separate folders together with its ArduHAL, and accesses its Arduino modules using the CommOptions commands. In these cases, a different Command Slot can be assigned to each ArduHAL. For the commands you can use any Slot (from 0 to 999) but be careful not to assign it to any Pin.

To assign a non-zero number to the Command Slot, manually edit the last line of the file "Theremino_ArduHAL_INI.txt". So to assign, for example, the Slot 300, you would write: `CommandSlot= 300`. Be careful not to delete the "=" sign. If something is wrong, the Slot zero is used, and the ArduHAL rewrites the corrected line in the INI file.

How to send commands

Currently two commands are defined:

- ◆ Recognize You send the "NAN_Recognize", or the number "1"
- ◆ Calibrate (*) You send the "NAN_Calibrate", or the number "2"
- ◆ Disconnect You send the number "771" (and ArduHAL releases the serial port)

(*) Currently (September 2018), there are not NetModule Pin types needing a calibration.

The applications that are NOT able to send the NANs (Not A Number) special numbers, can use the the numbers "1" and "2" instead of the "NAN_Recognize" and "NAN_Calibrate".

If you use the numbers "1", "2" and "771", they must be preceded by a sequence. This sequence has two numbers (333 and 666) that correspond to actually floating point numbers, with seven figures of precision, 333.0000 and 666.0000. So it is virtually impossible for an ADC or other devices to send this sequence by mistake.

Response messages

Responses, and error messages, are communicated with numbers in the command slot.

- ◆ -1 The "Recognize" command is still executing.
- ◆ 0 No modules have been found. The list is completely white.
- ◆ 1 and up The number of modules that has been recognized.
- ◆ NAN_MasterError One of the connected Masters has stopped communicating.

The "Command Slot" - Examples

To send the "Recognize" command you write:

```
----- VbNet
Slots.WriteSlot (0, NAN_Recognize)

----- CSharp
Slots.WriteSlot(0, NAN_Recognize);

----- Theremino Script
WriteSlot (0, NAN_Recognize)
```

As explained on the previous page, some applications (Theremino Automation for example) are not capable to use the NAN special numbers. Not using NANs the previous examples would become:

```
----- VbNet
Slots.WriteSlot (0, 333)
System.Threading.Thread.Sleep(50)
Slots.WriteSlot (0, 666)
System.Threading.Thread.Sleep(50)
Slots.WriteSlot (0, 1)

----- CSharp
Slots.WriteSlot(0, 333);
System.Threading.Thread.Sleep(50);
Slots.WriteSlot(0, 666);
System.Threading.Thread.Sleep(50);
Slots.WriteSlot(0, 1);

----- Theremino Automation
Slot 0 = 333
Wait Seconds 0.05
Slot 0 = 666
Wait Seconds 0.05
Slot 0 = 1

----- Theremino Script
WriteSlot (0, 333)
Threading.Thread.Sleep(50)
WriteSlot (0, 666)
Threading.Thread.Sleep(50)
WriteSlot (0, 1)
```

The 50 milliseconds waiting instructions are used to give time to the HAL to read the Slot.

The ArduHAL colors

The screenshot shows the Theremino ArduHAL software window. It has a menu bar (File, Tools, Language, Help, About) and a toolbar (Recognize, Validate, Error beep, Communication options, Disconnect Module). The main area contains a table of pin configurations and two panels on the right for module and pin properties.

Type	ID	Subtype	Slot	Value	Notes
Module	1	TestGeneric			Version 1
Pin	D0	Unused			
Pin	D1	Unused			
Pin	D2	Dig_out	2	0.0	
Pin	D3	Pwm_8	3	0.0	
Pin	D4	Unused			
Pin	D5	Pwm_8	5	0.0	
Pin	D6	Pwm_8	6	0.0	
Pin	D7	Servo_16	7	290.0	
Pin	D8	Unused			
Pin	D9	Unused			
Pin	D10	Unused			
Pin	D11	Unused			
Pin	D12	Unused			
Pin	D13	Unused			
Pin	A0	Adc_16	7	290.0	
Pin	A1	Unused			
Pin	A2	Gen_out_8	16	0.0	
Pin	A3	Gen_in_8	17	0.0	
Pin	A4	Gen_out_16	18	0.0	
Pin	A5	Gen_in_16	19	0.0	
Pin	A6	Gen_out_24	20	0.0	
Pin	A7	Gen_in_24	21	0.0	

Module properties

Name: TestGeneric

Rep freq. (fps): 219

Error rate (%): 0.00

Comm. speed: 12

Pin properties

Pin Type: Adc_16

Slot: 7

Max value: 1000

Min value: 0

Response speed: 30

The color scheme helps to recognize the components and their configuration

The Arduino (with TestGeneric name) provides twenty-Pin:

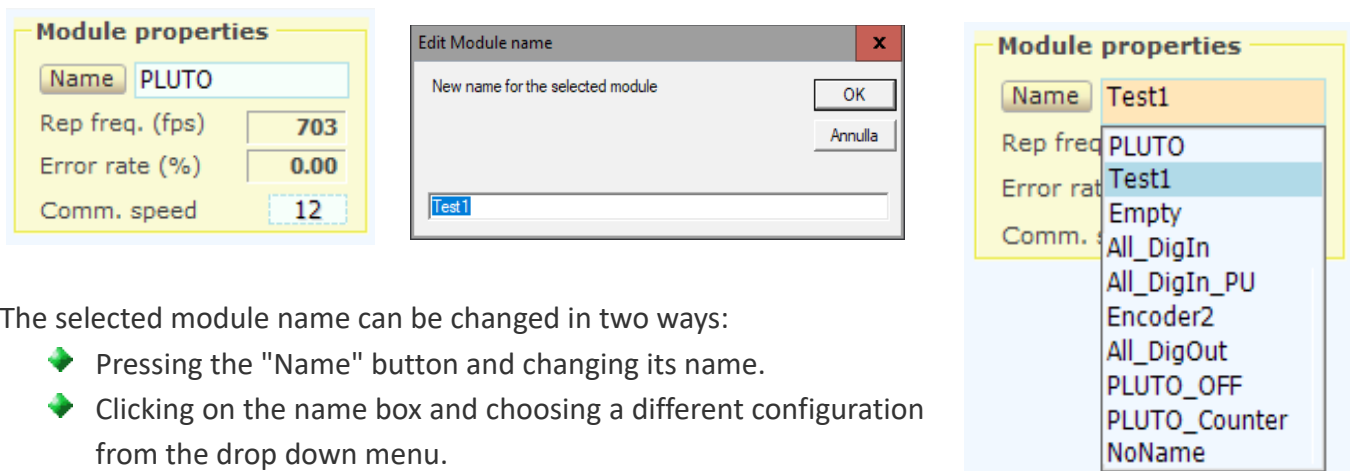
The Pins D0, D1, D4, D8 to D13 and A1 are "not used" and have a white background

The light yellow background Pins are outputs (DigOut, PWM, and servo GenericOut)

The light green background Pins are inputs (DigIn, ADC and GenericIn)

The blue line "Pin A0 Adc16" is the selected line and its properties are shown on the right.

Module properties - The name



The selected module name can be changed in two ways:

- ◆ Pressing the "Name" button and changing its name.
- ◆ Clicking on the name box and choosing a different configuration from the drop down menu.

The module name It is written to the hardware module and is used to recognize when you reconnect it.

A newly attached module is called "NoName" or "YYYYYYY". We suggest you to rename the card differently, to distinguish it from all the others.

While dialing the name, the letter case (uppercase or lowercase) does not count.

If in the data base there are two modules with the same name, then the first configuration is used for both the modules. It is therefore important to give different names to each module (unless you want to have a replacement module with the same name as the main one)

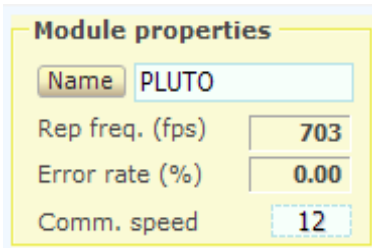
The modules are always listed in alphabetical order, so if you change the USB port then the module order does not change.

The HAL program almost always manages to use the right configuration when disconnecting, replacing and restoring components, but if you change the module names using a different computer or with another application (HAL located a separate folder - with separate parameters) or in other difficult and complicated cases, then the alignment between hardware and configurations could be lost.

If you lose the alignment you should restore the configuration manually, a Pin at a time, but experts can edit the configuration file and possibly copy this file entirely, or only a part of configurations, from a HAL application to another, on another computer or to another folder.

When the configuration is invalid to change the name of the module does not change the configuration file, but only the name written in hardware. You can then change the names of the modules to match them to the right ones in the configuration.

The module properties - Communication



Module properties	
Name	PLUTO
Rep freq. (fps)	703
Error rate (%)	0.00
Comm. speed	12

- Number of communications per second
- Percentage of errors on the serial line (usually zero)
- Communication Speed Adjustment

The number of messages per second "Fps" should normally be above 150 and often above 200, by increasing the number of Pin used this frequency may decrease slightly.

For many applications, a 100 fps is more than enough, for some applications it is good to keep fps high as possible, at least 200.

Applications that require maximum bandwidth, such as WaveAnalyzer can not use Arduino modules but must necessarily use a Master or a NetModule.

The percentage of errors normally is zero. You should have errors only in case of severe electrical noise or if you select a baud rate too high.

Tips to increase the "Fps"

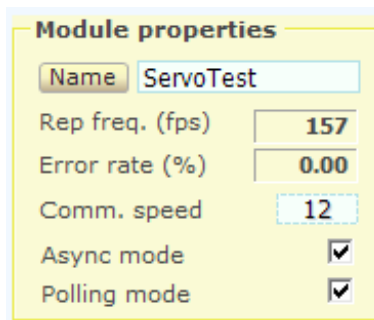
- ◆ Reduce the Arduino processor load (any instruction that wastes time in the Arduino "Loop" slows down the communication).
- ◆ Increase the "Comm Speed".
- ◆ Decrease the number of bytes used by configuring as "Unused" all possible Pins.
- ◆ Decrease the number of bytes used by configuring with 8-bit all the Pins that do not require greater resolution.
- ◆ Disable, if possible, the Async and Polling modes (see the next page).

Adjust the "fps" Frequency:

With the "Comm speed" value you can adjust the refresh rate "fps".

To increase the response speed would be good to maximize the exchange rate, and set "Comm Speed" to "12". But for many applications exchanges percent per second it is more than enough, so you can usually lower "Comm Speed" and charge less the PC CPU.

The module properties – Async and Polling modes



Module properties	
Name	ServoTest
Rep freq. (fps)	157
Error rate (%)	0.00
Comm. speed	12
Async mode	<input checked="" type="checkbox"/>
Polling mode	<input checked="" type="checkbox"/>

<-- Async mode
<-- Polling mode

Async Mode

If the async mode is enabled, the communication with the Arduino is no longer synchronous with the `loop()` function. Therefore the communication frequency (fps) is not slowed down by what the user writes in that function.

You can then use the `delay()` function even with very long waiting times. And you can get timings between events even without special techniques (state machines or interrupts) that for beginners would be completely incomprehensible.

Not always using the asynchronous mode is an advantage, but determining whether to use it is easy. Just check the repetition rate (fps) and use the async mode only if it increases the fps.

WARNING: If the Async mode is not enabled and the Arduino "`loop()`" function contains slow code, it may be impossible to communicate with Arduino and therefore it will not even be possible to enable the Async mode. In this case you will have to comment on everything in the Arduino "`loop()`" function, program it and press "Recognize". And finally enable the Async mode.

Polling mode

The polling mode (which means "cyclic interrogation") allows to use also the Arduino with the FT232 chip (for more information on the FT232 read this page).

Using the Polling mode decreases the exchange frequency (fps), but without it there would be continuous communication errors and therefore a tearing operation.

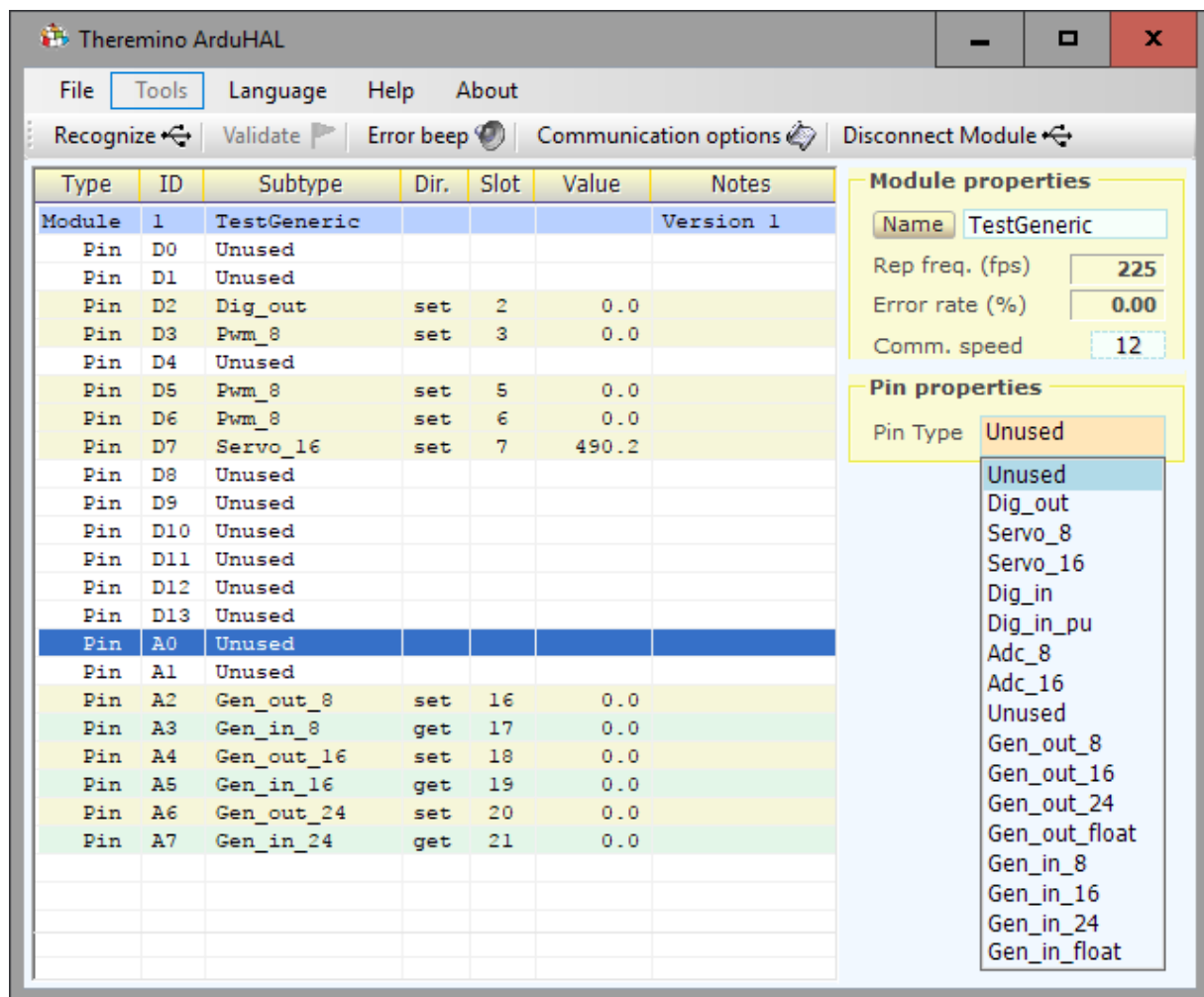
To determine whether to use polling you can proceed in two ways:

- ◆ Or check if there is an FT232 chip and in this case the polling mode is enabled.
- ◆ Or check the "Error rate" box.

Error rate (%)	0.28
----------------	------

If the box does not show 0.00, enable the polling mode. Then double check the error box, which should completely reset.

The Arduino modules and their Pin



The Pin are almost all the same and can be configured in many different ways.

- ◆ D0 ... D13 can not be configured as ADCs.
- ◆ A0 ... A7 can be configured in any way, including ADC.
(on some Arduino modules, for example the Nano, A6 and A7 works as ADC only)
- ◆ Only Pin D3, D5, D6, D9, D10 and D11 can be configured as PWM.
- ◆ If using pin type Servo then D9 and D10 can not be used as PWM.
We have not blocked these Pin Arduino because some models have different limitations.
More information about the Servo library on [This Page](#)

Our firmware was written and tested for the Arduino Nano.
And partially tested also on the UNO (that has only six Adc Pins instead of eight)
Some models could work partially or not work at all.
For some models, both the library and the ArduHAL application should be modified.

The Pin types

The Pins can be configured as:

- ◆ Not used
- ◆ Digital Output
- ◆ PWM output (490 or 960 Hz, depending on the pin)
- ◆ Output for servo-motors.
- ◆ Digital input
- ◆ ADC Input for potentiometers and transducers
- ◆ Counter, frequency and period inputs
- ◆ Generic inputs and outputs with 8, 16, 24 bits, or Float

Special Pin:

- ◆ The D0 and D1 Pins accept Gen_out and Gen_in only
- ◆ The D2 to D13 Pins accept all types, except the ADC
- ◆ The A0 to A5 Pins accept all types, including ADC
- ◆ On some modules A6 and A7 Pins works as ADC only
- ◆ Only Pins D3, D5, D6, D9, D10 and D11 can be configured as PWM
- ◆ When using Servo Pins then D9 and D10 are no longer working as PWM

Pin properties	
Pin Type	Unused
	Unused
	Dig_out
	Servo_8
	Servo_16
	Dig_in
	Dig_in_pu
	Adc_8
	Adc_16
	Unused
	Gen_out_8
	Gen_out_16
	Gen_out_24
	Gen_out_float
	Gen_in_8
	Gen_in_16
	Gen_in_24
	Gen_in_float

There are also the "Generic" Pins that can be used to communicate between the firmware and the PC. By means of these types it is possible to add some firmware and exchange numerical values through the application ArduHAL and finally with the slot of the Theremino system. You may for example read sensors connected in I2C and send values to your PC. More information on generic Pin in the page [The Generic pins](#).

All pin can also be configured as "Not used". This allows to decrease the number of bytes passing on serial and USB line and maximize the number of exchanges per second.

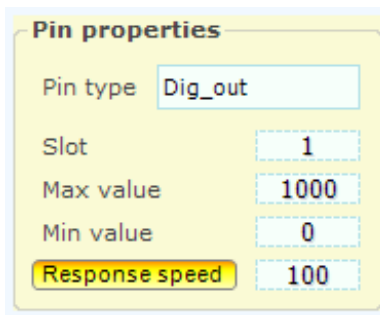
The choice between 8, 16, 24 or Float, Available for some types of Pin, it allows to have the maximum resolution (24 o Float), or a lower resolution (8 bits) but a higher bit-saving and thus a higher communication speed.

The types with pullup, Whose name ends in "_pu", allow to easily connect switches, buttons and open-collector devices, without having to add external resistors (pullup current typical = 250 uA).

These types of Pin are valid for **Arduino Nano**, but pay attention to A6 and A7.

Other Arduino models have similar capabilities but we have not tested them.

The parameters common to all Pins



Pin properties	
Pin type	Dig_out
Slot	1
Max value	1000
Min value	0
Response speed	100

"**Slot**" indicates where to write or read data. The slots are a thousand, numbered from 0 to 999, and can be read or written by all Pins and all the Theremino System applications.

Please note: Many applications and Pins can read from the same Slot, but avoid to configure more than one Pin, writing to the same Slot. Doing so doesn't damage anything, but the results are undefined.

"**Max value**" normally set to 1000, indicates the value that the Pin must have, when at its maximum.

"**Min value**" usually set to zero, indicates the value that the Pin must have, when at its minimum.

By adjusting Max and Min, with values other than 0 and 1000, you can achieve any scale ratio and calibration. If you exchange the two values (min value larger than max), then the scale is reversed, this is useful to reverse the movement of the actuators or to turn the readings of sensors, that act reversed.

"**Response speed**" adjusts the filter IIR (Infinite Impulse Response) for the best compromise between noise and response speed. With a value 100, the filter is disabled and the maximum speed of response is obtained. The value 1 produces the maximum filtering, (elimination of any jitter) but a very slow response (approximately one second). Normally we use the value of 30, which provides a good filtering and a fast enough speed.

If the "**Response speed**" button is pressed, the IIR filter adapts to variations in order to obtain a higher reactivity, when there are wide variations and a greater damping, when the changes are minor. As a result you get a good stability of the digits, without too much sacrificing the settling time.

Some sensor signals may malfunction with "**Response speed**" pressed. This is specially true for sensors producing a signal with little variations around a high base value. In this case the signal never arrives to the final value or is very slow to arrive. If you experience this, disable "**Response speed**".

The IN-OUT range of 0V to 5V is valid for the Arduino Nano, other modules could be different.

The "Output" Pin types --> Dig / PWM / Servo

◆ Dig_out

Pin properties	
Pin type	Dig_out
Slot	1
Max value	1000
Min value	0
Response speed	100

This type of pin provides a digital output.

The value coming from a Slot, limited between "Min value" and "Max value" and filtered by "Response speed", is compared with the value between "Min value" and "Max value". If exceeded, the Pin turns on, otherwise off.

The Pin can only assume voltages 0V (off) and 5V (on) and the output current is limited to approximately +/- 10 mA

◆ Pwm_8 and Pwm_16

Pin properties	
Pin type	Pwm_16
Slot	1
Max value	1000
Min value	0
Response speed	100

PWM properties	
Max time (uS)	4000
Min time (uS)	0
Logarithmic response	<input type="checkbox"/>

This type of Pins provide a PWM (pulse width modulation) output.

The value coming from a Slot, limited between "Min value" and "Max value" and filtered by "Response speed", is converted to pulses of width between "Min time (uS)" and "Max time (uS)"

The frequency of the pulses is 2000uS (500Hz) fast enough to turn on a LED with variable intensity. For users who require a real variable voltage a low pass filter is added, usually composed of a resistor and a capacitor.

The Pin provides pulses between the voltages 0V (off) and 5V (on) and the output current is limited to approximately +/- 10 mA

◆ Servo_8 and Servo_16

Pin properties	
Pin type	Servo_16
Slot	1
Max value	1000
Min value	0
Response speed	100

Servo properties	
Max time (uS)	2500
Min time (uS)	500

This type of Pin controls servo motors directly.

The value coming from a Slot, limited between "Min value" and "Max value" and filtered by "Response speed" is converted to pulses of width between "Min time (uS)" and "Max time (uS)"

The pulses repetition time is adjusted to normal aero-model servo, spinning around 180 degrees, between the min and max time.

The Pin provides 0V to 5V, adequate for normal 4 to 6 volts servos and a current sufficient to drive dozens of parallel servo.

The types of Pin in "Input" <-- Dig / ADC

◆ Dig_in and Dig_in_pu

Pin properties	
Pin type	Dig_in
Slot	1
Max value	1000
Min value	0
Response speed	100

This type of Pin provides a digital input.

The voltage value is read with a Schmitt Trigger, with low threshold = 1.5V and high threshold = 3V, and transformed into a On/Off information and finally to "Max value" or "Min value". The value is then filtered with "Response speed" and finally written into the Slot. The filtering produces intermediate values, roughly proportional to the ratio of time, between On and Off.

◆ Adc_8 and Adc_16

Pin properties	
Pin type	Adc_16
Slot	1
Max value	1000
Min value	0
Response speed	30

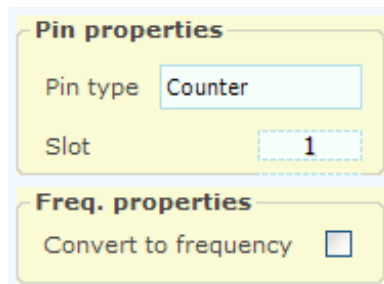
This type of Pin provides an analog input.

The voltage value from 0V to 5V is converted into a number between "Min value" and "Max value." The value is finally filtered with "Response speed" and then written into the slot. The filtering reduces the noise present in the input signal, but slows down response. The value 30 represents a good compromise between speed and noise.

The "Input" Pin types <-- Counter

This type is not currently implemented in the Arduino firmware.

◆ Counter and Counter_pu



Pin properties

Pin type

Slot

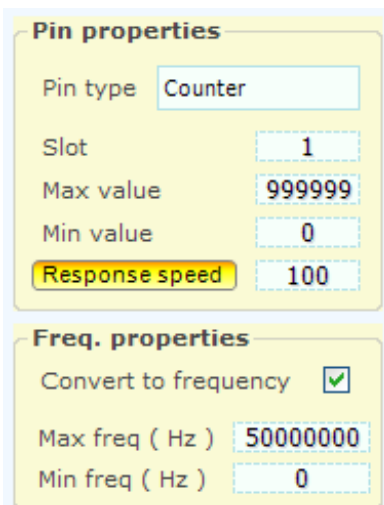
Freq. properties

Convert to frequency ☐

All Pins can be programmed as Counter or Counter_pu but the maximum counting speed is quite limited, around a few KHz, depending on the load on the microcontroller and the duty-cycle of the signal.

If you need a higher speed you have to use a FastCounter on Theremino Master.

◆ Counter and Counter_pu with the "Freq" option



Pin properties

Pin type

Slot

Max value

Min value

Response speed

Freq. properties

Convert to frequency ☒

Max freq (Hz)

Min freq (Hz)

Pins programmed as Counter or Counter_pu, can be transformed from counters to frequency-meters.

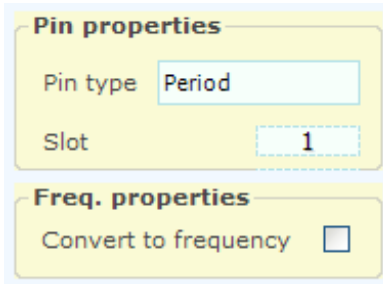
The frequency value, limited between "Min Freq" and "Max Freq", is then compared between "Min value" and "Max value" filtered with "Response speed" and finally sent to the Slot.

The "Counter" and "Counter_Pu" Pin-types use 16 bits for data transmission.

The "Input" Pin types <-- period

This type is not currently implemented in the Arduino firmware.

◆ Period and Period_pu

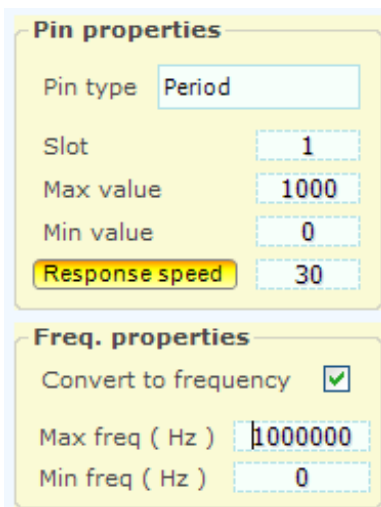


The screenshot shows a 'Pin properties' dialog box. Under 'Pin properties', 'Pin type' is set to 'Period' and 'Slot' is set to '1'. Under 'Freq. properties', the 'Convert to frequency' checkbox is unchecked.

This type of Pin, measures the period of a repetitive waveform, from peak to peak, up to a maximum period of about 260 seconds.

Resolution is half a microsecond and accuracy is +/-1%, over a range of temperature from 0C to 50C.

◆ Period and Period_pu with the "Freq" option



The screenshot shows a 'Pin properties' dialog box. Under 'Pin properties', 'Pin type' is set to 'Period', 'Slot' is '1', 'Max value' is '1000', 'Min value' is '0', and 'Response speed' is '30'. Under 'Freq. properties', the 'Convert to frequency' checkbox is checked, 'Max freq (Hz)' is '1000000', and 'Min freq (Hz)' is '0'.

Pins programmed as Period or Period_pu can be transformed from counters to frequency-meters.

This technique, allows to measure very low frequencies (up to about a tenth of a Hertz) with very high resolution.

The value of frequency, limited between "Min Freq" and "Max Freq", is compared between "Min true" and "Max value", filtered with "Response speed" and finally sent to the Slot.

The "Period" and "Period_pu" Pin-types use 32 bits for the data transmission.

The "Generic" Pin types

What we explain in this page is only for read or write special sensors or actuators, such as motors or sensors that communicate over I2C. Or to pre-condition the data with its own firmware before sending it to PC or from PC to the actuators.

To read and write the normal inputs and outputs is not necessary to use the functions explained in this page, just set up the Pins with the ArduHAL and they work immediately.

In the next rows the fundamental eight types are shown

- ◆ The first couple re-sends to the ArduHAL (on Pin 1) the 8 bit value coming from Pin 0
- ◆ The other two couples do the same with 16 and 24 bits and using Pins a0, a1, a2 and a3
- ◆ The last couple do the same with float numbers, using Pins 5 and 6

```
uint32_t n; float f;

n = Theremino.genericRead8 (0);
Theremino.genericWrite8 (1, n);

n = Theremino.genericRead16 (A0);
Theremino.genericWrite16 (A1, n);

n = Theremino.genericRead24 (A2);
Theremino.genericWrite24 (A3, n);

f = Theremino.genericReadFloat (5);
Theremino.genericWriteFloat (6, f);
```

Once these rows are written in the Arduino function "Loop", you can test them with the ArduHAL, modifying the value in the "Value" column with the mouse, or using the SlotViewer app.

In the GenericWrite and GenericRead functions you must indicate a Pin to use and that same Pin must be configured in the ArduHAL with the corresponding types Gen_in or Gen_out. If you make mistakes you will have unpredictable results.

The Pin are all valid to communicate "generic data". For the Pin name you can use a number from 0 to 21. For the last eight Pin you can also use the names A0 to A7.

We recommend that you use D0 and D1 first, which can not be used as physical Pins.

When in the ArduHAL you set a Pin as generic, the correspondent physical Pin is no longer read (or written) by our firmware, but you will have to write the necessary firmware. So to use these functions you must know how to plan and organize without errors, and it takes a good experience in programming.

The "Read an I2C sensor" document that, you download from [This Page](#), is a good example of using Generic Pins.

Usage of the "Generic" Pin types

Send data from the sensors to the ArduHAL, and finally to the PC applications

- ◆ Choose a Pin
- ◆ In the Arduino Loop, read the sensor and interpreting its data
- ◆ In the Arduino Loop, send data with "GenericWrite" (8, 16, 24 or Float)
- ◆ In the ArduHal, get the data by configuring the Pin as Gen_in (8, 16, 24 or Float)
- ◆ In the ArduHal, set the Pin with a Slot through which the data of the sensor will go to the applications that use it.

Send data from PC applications to the ArduHAL PC, and then to the hardware

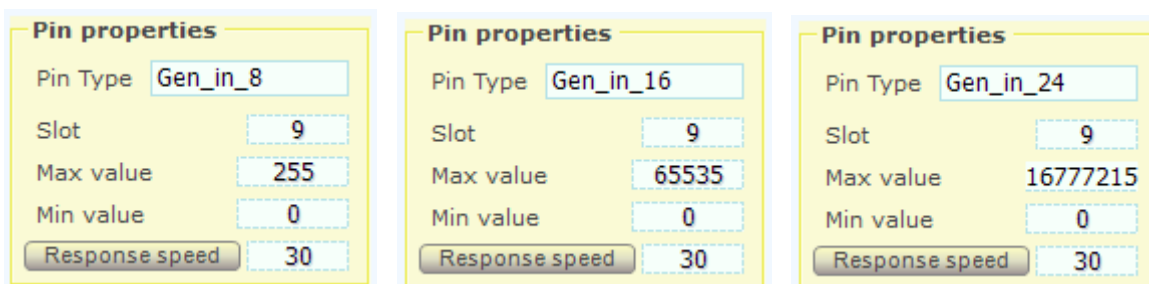
- ◆ On the ArduHAL, choose a Pin
- ◆ On the ArduHal, set the Pin with a Slot through which to get numeric data form PC apps.
- ◆ On the ArduHal, send data to Arduino configuring the pin as Gen_out (8, 16, 24 or Float)
- ◆ In the Arduino Loop, read the data with GenericRead (8, 16, 24 or Float)
- ◆ In the Arduino Loop, interpret and translate the numeric data and send it to the hardware.

Transfer integer numbers from Arduino to PC Slots and vice versa

Most used are the 16 bits integers (0 to 65535). But in some cases they could be small values and therefore stay in 8 bits (from 0 to 255), or very large values and therefore need 24 bits (from 0 to 16777215).

The standard of the Theremino system is to relate all these values to a "normalized" range from 0 to 1000. But in some cases, such as a sensor that provides an integer value, it may be useful to transfer the value without modifying it.

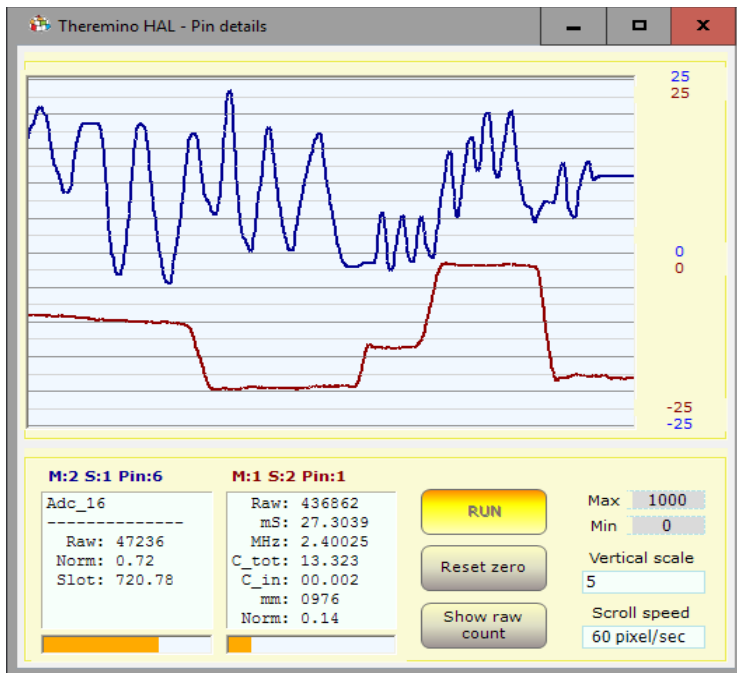
To achieve this behavior change the "Max value" box with a value appropriate to the number of bits that are used, as seen in these images.



Transfer Float numbers from Arduino to PC Slots and vice versa

Float numbers, called Float or Double on Arduino, or Single in the PC applications, can be huge or very small and always have the same accuracy. These numbers are transferred as they are, if you set "Min value = 0" and "Max value = 1000". Otherwise you can use "Min value" and "Max value" to scale them as you wish.

The “Pin details” viewer



With a double-click on a active Pin line, this instrument is opened. To display two signals click on the first Pin then on the second Pin, with a single click.

The vertical scale can be set to “Scale Min-Max”, which corresponds to the Min and Max textbox values.

Or it can be set in 24 levels from 0.01 to 50000 points per vertical division (ten dark lines). When the vertical scale is set to those values, to center the traces you press "Reset zero."

In some cases it may be useful to check the raw values. For "Raw" values, use the "Show raw count".

The "Scroll speed" adjusts the graph scroll speed, from 0.1 pixel per second to 60 pixel per second.

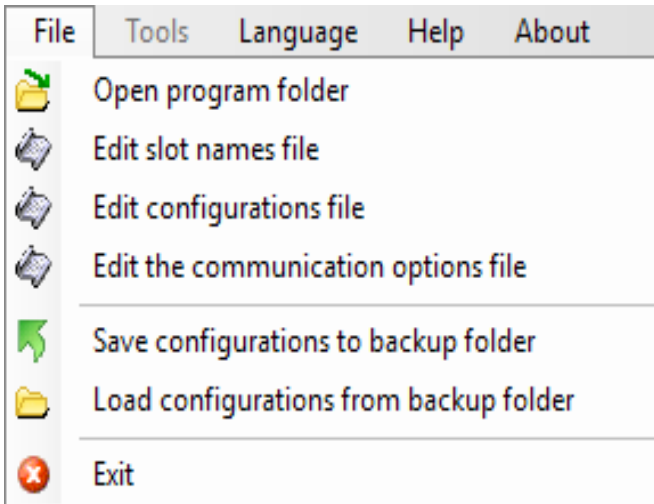
The two text boxes show the internal details of the Pins. In this image the text indicates what Module and Pin is. The text "M:1 Pin:2" means "Module 1, Pin 2".

The Pin details can help in the control and regulation of Output Input devices (sensors and actuators).

Some Pin types are more complex and have more intermediate values. Typically there is a "Raw" value with values very variable depending on the type of Pin, a "Normalized" value that always goes from 0 to 1, and a "Slot" value which normally ranges from 0 to 1000 and which is the simplified value available on Slots and easily usable by all the high-level software.

- ◆ **Raw** "Raw" value that can be a count, a time, a voltage or otherwise.
- ◆ **mS** Time in milliseconds
- ◆ **uSec** Time in microseconds
- ◆ **Smoot** Value that was passed in a FIR filter (only used in Cap8 and Cap16)
- ◆ **Mean** Average value (used in type Cap8 and Cap16 as zero calibration)
- ◆ **Norm** Normalized value between zero and one
- ◆ **Slots** Value written to or read from the slot associated with the Pin (normally 1 to 1000)
- ◆ **Out** Digitized value that can be processed only in "0" or "1" (used by DigOut only)

Menu commands



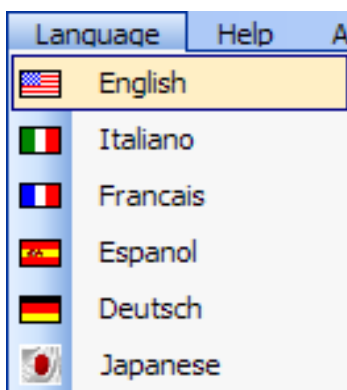
Open the program folder it may be useful to modify the documentation files and languages.

Edit the file: "SlotNames" Comments (or slot names) are explained on [this page](#).

Edit configurations it may be convenient in some cases. For more info, please read "Questions and Answers" on the last page of this document.

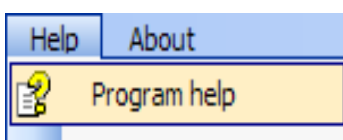
Change communication options the communication options file is opened to modify ports (Com1, Com2, etc ...), the speed (baud rate) and the names of modules to recognize. In the communication options file the choices are explained.

Save the configuration as a backup It allows to make the configurations of the security copies. If the configuration files are modified by mistake you can then load them from a previous version. Previous versions show the date and time they were saved.



The language files are located in the "Docs" folder next to ThereminoHAL.exe application.

To make new language files just copy the file Language_ENG.txt, change "ENG" with "FRA", "ESP", "DEU" or "JPN" and edit text with Notepad.



This command opens the documentation files.

Toolbar Commands



Recognize

It recognizes the connected Arduino modules. The modules are searched using the the Comm Ports, Baud Rates and Names specified in the Communication Options.

Valid

When you add or subtract modules, you could be advised that the configuration has changed with red lines in the list. If you choose to lose your old configuration and adapt existing hardware, with this button you will make the new configuration effective.

Mistakes

When pressed communication errors are highlighted with a sound.

Communication Options

The communication options file is opened to modify ports (Com1, Com2, etc ...), the speed (baud rate) and the names of modules to recognize. In the communication options file the choices are explained.

Disconnect Module

Deletes the selected module from the list. This way you can delete unwanted modules without having to physically disconnect them from the USB.

Isolated Applications

Some Theremino system applications automatically launch its own ArduHAL. This happens if there is a Theremino_ArduHAL.exe in the folder ThereminoArduHAL located near to your application EXE file. You could also place Theremino_ArduHAL.exe next to the exe file of the application, but it is better that the ArduHAL has its own folder, with the “Docs” sub-folder containing documentation and language files.

These ArduHAL use their own private configuration and connect to Modules with the name in the file CommOptions. An application composite in this way, will continue to operate even when copied to a different computer, and even if other Theremino System applications are connected with their Modules, on other USB ports.

The applications that benefit most from these possibilities, are applications with a specific task, such as: Theremino Geiger, Theremino OilMeter, Theremino Weather, Theremino Theremin, Theremino Arm, Theremino Geo and Theremino EmotionMeter.

This does not mean that isolated applications can not communicate with each other. The modular communication is always possible and is done through the Slot, which are common to all applications.

To avoid using the same Slot for different tasks we have defined a broad pattern:

```
Experimental 100 slots 000-099
- - -
Theremino_Theremin 100-199
Theremino_SlotsToMidi 200-299
Theremino_MusicKeys 300-329
- - -
469 free slots 330-799
- - -
Theremino_OilMeter 800-809
Theremino_EEG 810-819
Theremino_Meteo 820-839
Theremino_Arm 840-849
10 free slots 850-859
10 free slots 860-869
10 free slots 870-879
Theremino_EmotionMeter 880-889
Theremino_Geiger 900-909
Theremino_Bridge 900-909
Theremino_GEO 910-919
Theremino_GeoPreampTester 920-929
Theremino_Radar 930-939
10 free slots 940-949
10 free slots 950-959
10 free slots 960-969
10 free slots 970-979
10 free slots 980-989
10 free slots 990-999
```

This scheme is only indicative. You can use the Slots as you like, providing that, the same Slots are not used for different tasks in the same PC. If you make a mistake does not break anything, but the data overlap with undefined results.

Adjusting the numerical boxes

Draw speed (fps) 5

HAL numerical boxes (and all other Theremino system 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

- By clicking and holding down the left mouse button and moving the mouse up or down
- With the mouse wheel
- By pressing the arrow-up and arrow-down keys
- With conventional methods used to write numbers with the keyboard
- With the usual selection and copy-paste methods
- By pressing SHIFT the variation speed is multiplied by one hundred
- By pressing CTRL the variation speed is multiplied by ten
- By pressing ALT the rate of variation is divided by ten

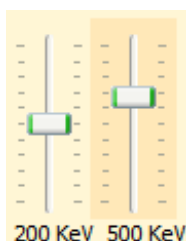
Moving the mouse up and down allows wide and fast adjustments

The mouse wheel allows a comfortable and immediate setting

The arrow keys allows fine adjustments without having to look away from what you are adjusting

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

Adjusting the sliders



These are the original Microsoft cursors, they are pretty comfortable, so we just added the orange color and the possibility to reset them.

<<< Non-zero sliders are marked with an orange color, to reset them just click with the right mouse button (not all sliders have a zero, in this case they do not change color and cannot be reset with the mouse)

Sliders can be adjusted in the following ways

- Clicking the cursor with the right mouse button, to reset them
- Clicking the cursor with the left mouse button and moving the mouse up or down
- With the mouse wheel
- Using the left-arrow and right-arrow on your keyboard
- By pressing the up-arrow and down-arrow keys

The method of moving the mouse up and down, allows wide and fast adjustments.

The mouse wheel allows comfortable and immediate adjustments

The arrow keys allow fine adjustments without taking your eyes from what you are adjusting.

The arrow keys left/right or up/down have the same effect, it might be more intuitive to use the first for horizontal cursors and the second for vertical sliders.

Questions and answers

Can I edit the text of the program panels in different languages?

Certainly, just edit the files: ".. \Docs\Language_Eng.txt" and ".. \Docs\Language_Ita.txt"

For languages German, French and Spanish just copy the English file three times with the following names: ".. \Docs\Language_Deu.txt", ".. \Docs\Language_Fra.txt", ".. \Docs\Language_Esp.txt" and edit them.

Can I edit the configuration file?

Normally the association between configurations and modules is kept aligned by the HAL, which uses the names of the modules to determine the proper configurations to be taken. Normally the HAL can use the right configuration even if you disconnect and replace modules.

In some cases, if you change your name to the modules with a HAL that is on a different computer, or to a different folder, then the you lose alignment between hardware configuration. In these cases, you can click on the drop down drop down the name of the form and restore the alignment by choosing the right configuration for each module.

To make more complex changes, you can open the "Theremino_HAL_ConfigDatabase.txt" file, with a text editor such as "Notepad", and manually edit the configurations that are quite simple.

How to reduce the CPU work?

- Close or minimize the "Component window details".
- Minimize the main window.
- Reduce the "Speed", as explained in the opening pages of this document.