System theremino

Slave
CapSensor

The "CapSensor" slave

The "Cap Sensor" measures the distance of a conductive object (typically an hand)
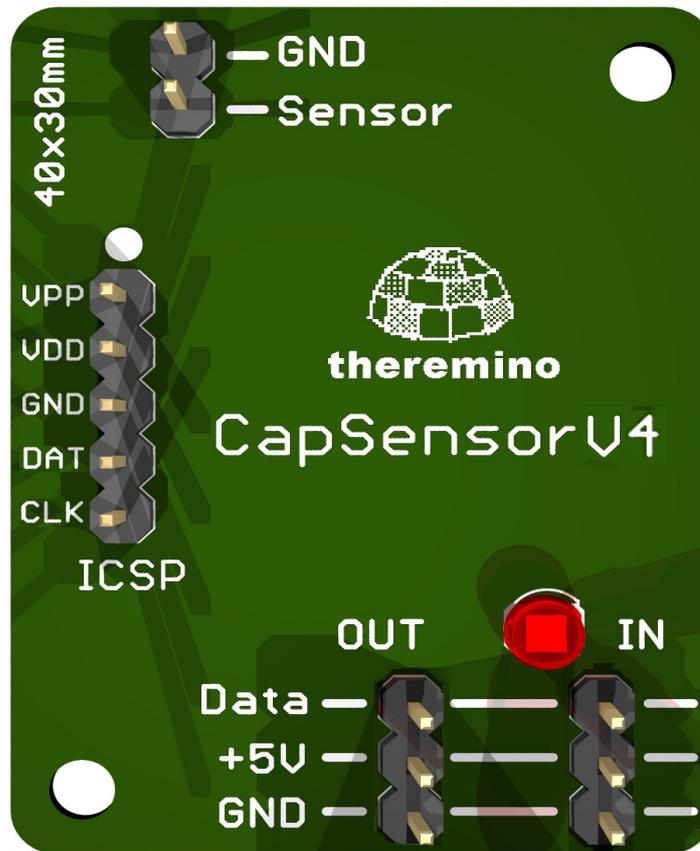
In the range of distances from a few centimeters to a few meters it provides performance unattainable by any other means of detection.

Unlike the ultrasonic sensors the measurement is always gradual, can not in any way "jump" from a distance to another, due to the reflections of the signal or the detection of multiple obstacles. The detection is always stable and precise with a fast response time, in the order of milliseconds.

The CapSensorHQ is perfect to control with your hand in a linear and always soft fashion the characteristics of sound and video, such as Waveform (wav, mp3, etc..) And movies / video clip (avi, mpg, mp4, etc..)

Since September 2012 is available version 3 of CapSensor (visible in this picture) with improved stability characteristics. Even here the screw connectors have been replaced with the connectors for the extension male-female. These connectors are not as beautiful to look at but they are more convenient to use and reliable.

Configure the slave "CapSensor"

The CapSensor has only one "PIN" which can be configured as:

- Not used
- CapSensor
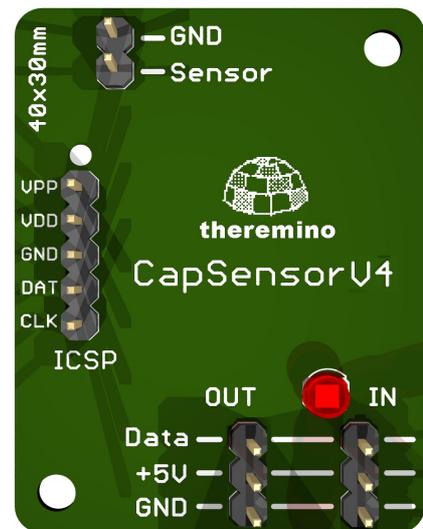
Features

• Range of measurable capacitance: 0.001 pF to 10 pF

• Resolution: one thousandth of a pF

• Stability: about a thousandth of pF

• Detection of small objects (hand): up to a few meters

• Detection of large objects (a car): up to tens of meters

• Accuracy and stability on the distance detected: from a few mm to a few tens of cm

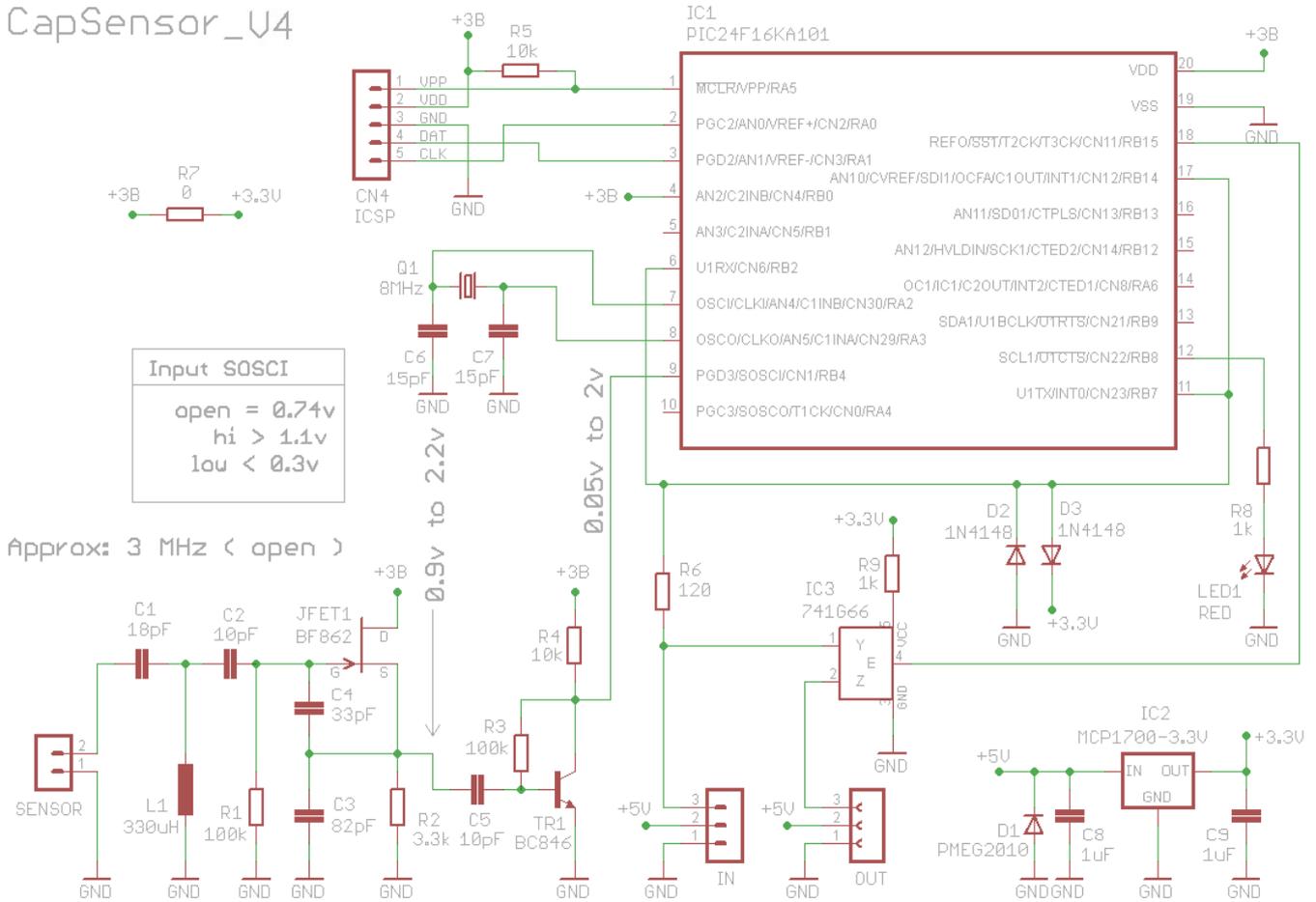• Sensor size varies from square centimeter to square meter

Technology

A low-noise FET and the analog-digital conversion to 24 bits allow to obtain an extreme sensitivity, and a great stability, measuring a very small capacitance.
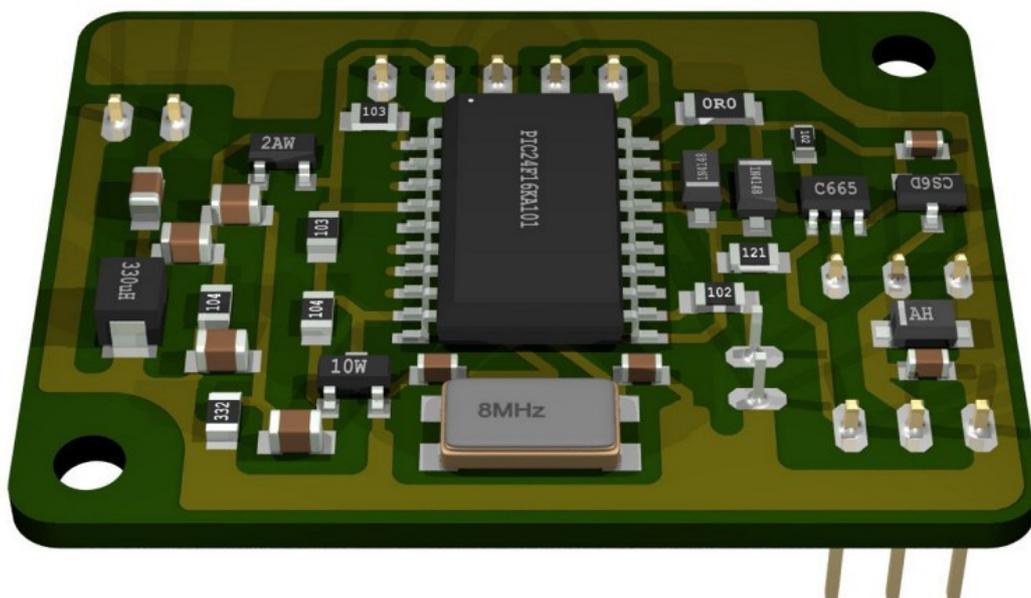
Electric schematics

CapSensor_V4

IC1
PIC24F16KA101

Input SOSCI

open = 0.74v
hi > 1.1v
low < 0.3v

Approx: 3 MHz (open)

The connector Sensor and the components L1, C1, C2, C3, C4, C5, R1, R2, R3 and R4 form an oscillator with a very low noise, almost a front-end for radio receiver, and compose, together with the PIC, a 24-bit ADC being able to follow infinitesimal changes in capacitance, with stability of one part in two million.

The regulator IC2 and components of power circuits C8 and C9 stabilize the very inaccurate 5Volt and noisy in the USB to a well stabilized 3.3 Volt. The use of two ceramic capacitors of high capacitance (a big 1uF) allows to eliminate to the maximum the noise of powering up the FET.

IN connector: It connects to the master or to the previous slave of the chain and allows the bidirectional serial communication. The resistor R3 decreases the slew rate to prevent noise radiated radio frequency.

OUT connector: Returns the serial line for the following slave of the chain. The bilateral switch IC3 enables or disables the following slaves, for the recognition and auto-configuration of the modules. The resistor R9 protects IC3 from reverse polarity, short circuit or between power and signal caused by bad connection.

The ICSP connector allows you to program the micro controller with a PicKit1 / 2 or 3, for firmware upgrades or to add new features.

The quartz crystal Q1 with C6 and C7, provides a very stable timing, required for this circuit.

LED1 provides a visual indication of proper operation. The rate of change is twenty times the speed of flashing, if the led flashes fast all is OK.

Operation

The operation is based on an initial measure called "calibration" which stores the capacitance value of the sensor in rest conditions. Following the approach of any conductive object, a hand or a metal object, increases the sensor capacitance of a very small amount proportional to the distance between sensor and object.

By means of a low noise FET and a 24-bit ADC converter it is able to accurately measure changes in capacitance small, even less than one thousandth of a picofarad, and provides the software to measure a digital value very precise and stable.

The measurement software, which is located in the HAL program, taking account of the calibration value, and the parasitic capacitances and the physical laws that bind areas, distances and electric capacitance, performs a calculation very complex which converts the raw data into a distance value pretty linear.

The CapSensorHQ is less precise and less linear than a distance sensor ultrasonic but has a unique property, the gradualness of the distance measure which can not in any way "jump" between two values.

The graduality and the response speed of CapSensorHQ are not obtainable with any other sensor. Only with CapSensorHQ you can drive sound and video in an always linear and pleasant way.

Sensor operation

The sensor is composed of a simple plate of copper, aluminum or can be any conductive object, also of non-regular shape. There is no need that it be a metal object, any material even weakly conductive, can work well.

The sensor is connected to the pin marked "Sensor" with an unshielded wire and not very long (a few inches to a few feet at most)

The pin labeled "GND" can be left unconnected or connected to a metal mass of reference which, in some cases, can stabilize the measure, reduce noise and increase the maximum usable distance. The reference mass must be connected with a wire no longer than a few tens of centimeters and should not be facing the sensor or be too close to it, because otherwise the capacitance of the sensor would increase too much and the radius of action would be reduced.

The sensor surface may range from a few square centimeters up to about one square meter. With large sensors a large radius of action of many meters is obtained, with little sensors with the radius of action is reduced to a few tens of centimeters.

The sensor and its wire connection must be positioned away from metal parts and electronic circuits that can cause disturbances. Typically the distance to be respected is comparable to the radius of action desired.

If you use multiple CapSensorHQ then their sensors must be distant from each other by a distance comparable to their radius of action. If they are too close can happen that we influence each other, you can check if you are coupled together by checking whether their frequencies are the same (the frequencies are read in the Pin properties of the HAL program). To prevent interference of adjacent two sensors it is possible to apply a capacitor 15pF (NPO) between terminals GND and Sensor of only one of them (if there are only two), or on all the odd-numbered sensors (if there are many)

Connect the Slave modules

The cables to connect the serial line that goes to the slave are the same that are used to connect sensors and actuators to Input / Output Pins.

But you should not confuse the two lines, wiring errors not cause damage, but if you do not make the right connections, these will not work.
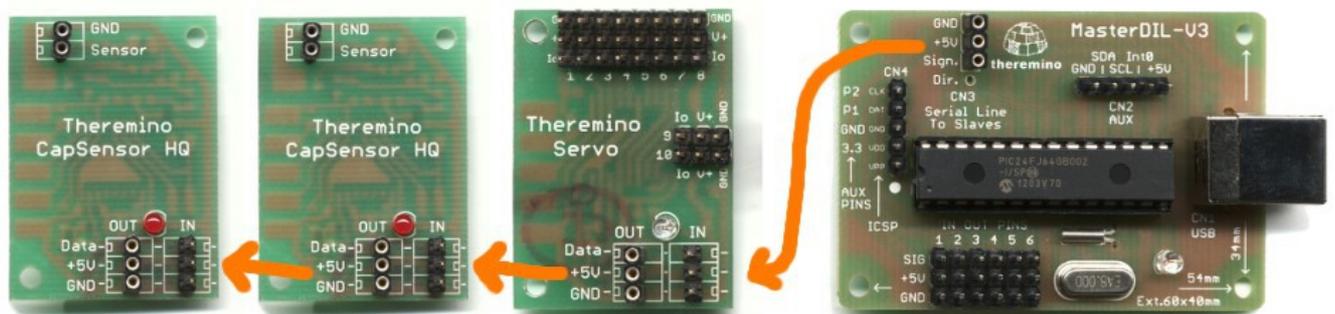
Even if the connectors are the same, be careful! Connectors "Pin" are used for sensors and actuators while the connectors "Serial" are used to connect modules "Master" and "Slaves" to each other.
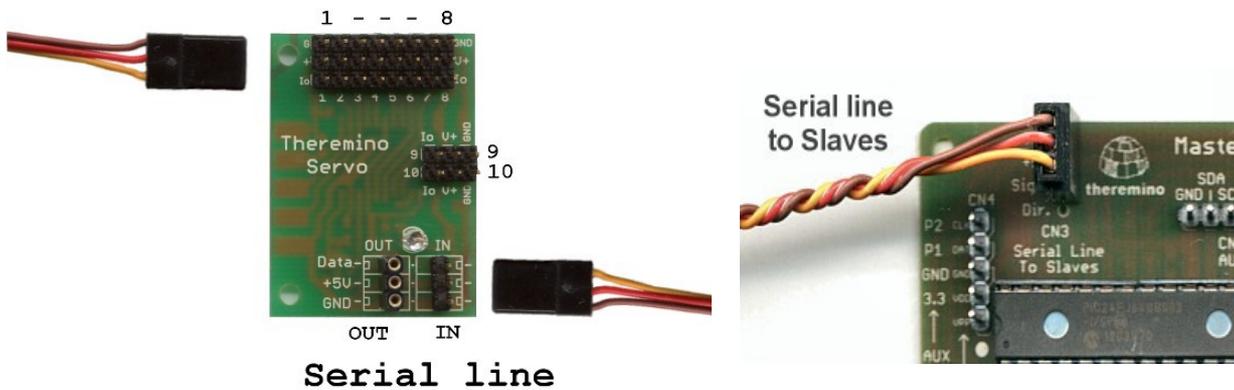
The serial line from the Master must be connected to the "IN" of the first "Slave"

To add a second slave use the "OUT" connector of the first slave, and so on up to 200 slaves.


The slaves can be connected in any order but if you change them or their number the hardware configuration is misaligned from the HAL program

Thus, after composing the chain of Masters and Slaves, press the button "Recognize" and then eventually "Validate" to accept the new hardware configuration to Theremino_HAL

Musical Instruments

With CapSensorHQ and capacitive keys of the Master joined the Theremin (Polyphonic Synthesizer) can be built in addition to the Theremin also any other kind of musical instrument, from classic keyboards, laser harps.
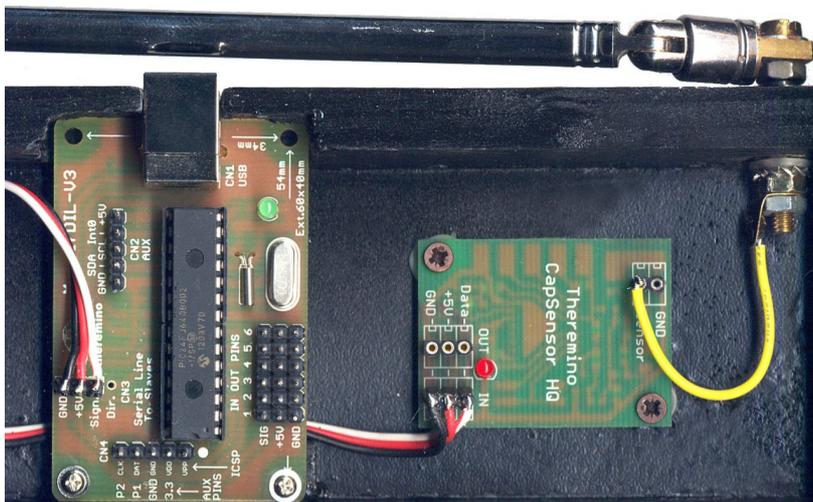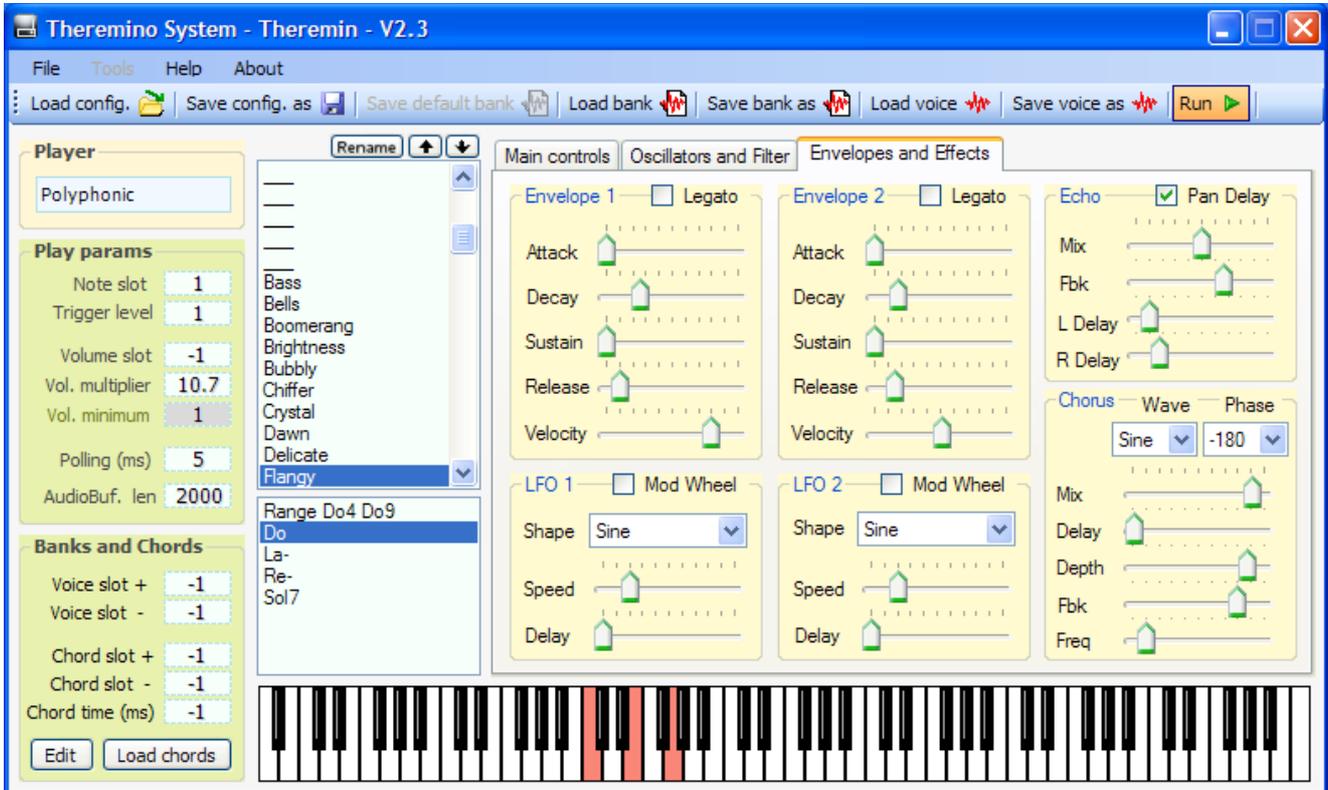
You can also easily create and invent new tools, highly scenic and never seen before.

More information in the instruction sheets Theremino Theremin application that you download from here:
www.theremino.com / downloads / multimedia

Advice

The CapSensor is not made to measure capacitors, as if it were a tester. Firstly could measure only small capacitance and then you should calibrate it for points, with a laborious procedure, in order to have even just a minimum of precision and linearity.

The CapSensor are used for process control, to adjust positions and adjust a volume or scroll through a video. In these applications it is important to make absolute measurements but it is essential to do many tens of measurements per second.

For control applications, you do not need to know the exact value but, on the other hand, the value must be very stable, and have the least possible noise so you do not "shake" the object under control.

This reasoning made for the CapSensor is, in general, valid for all the variables of InOut system Theremino

The system Theremino works with ultra-high resolution, up to one part in 65000, much higher than the resolution of a normal tester (1 part in 2,000), also the values are very stable, low noise and sampling rates are higher by hundreds if not thousands of times compared to those of a tester.

On the other hand the accuracy of the measurements is poor. With standard input-output Pin, the achievable accuracy is of the order of one percent, and it can be up to 0.1% or so, with a hardworking individual calibration.

Scalability of the system

Although the system can withstand up to 200 Servo modules, there are limits to the speed of the serial line communication, limitations due to the demands of total reliability and limits the ability to manage systems of great complexity with a simple list of Pins.

We therefore recommend to restrict the systems to a few dozen modules, and then the Input Output to a few hundred. During the design of large systems consult us or experiment to see if the speeds obtainable are sufficient and whether the final system is sufficiently reliable, and manageable.

Precautions to be taken

The system is a project Theremino "Freeware", "Open Source" and "Not for Profit" and its components are "mounting kit" and not "finished products".

Therefore **who is responsible for connecting the modules in a system, comply with the limits of the law** radio frequency emissions and obtain necessary certifications. To reduce noise limits of law might be necessary, depending on the case, use shielded cables and metal containers or other devices.

Manufacturers and retailers of the system Theremino are not aware of the actual terms of use of forms and therefore can not respond to improper use, illegal or dangerous of them.

For more information, see this page: *www.theremino.com / contacts / copyrights*