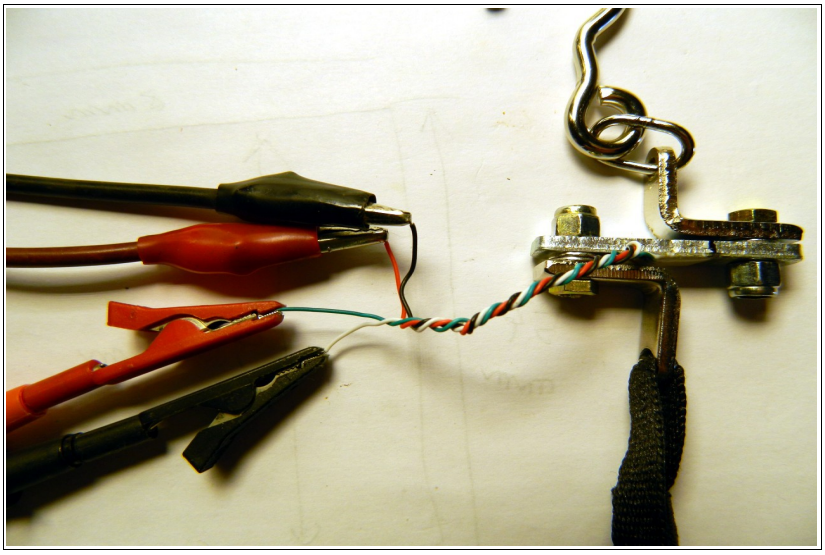
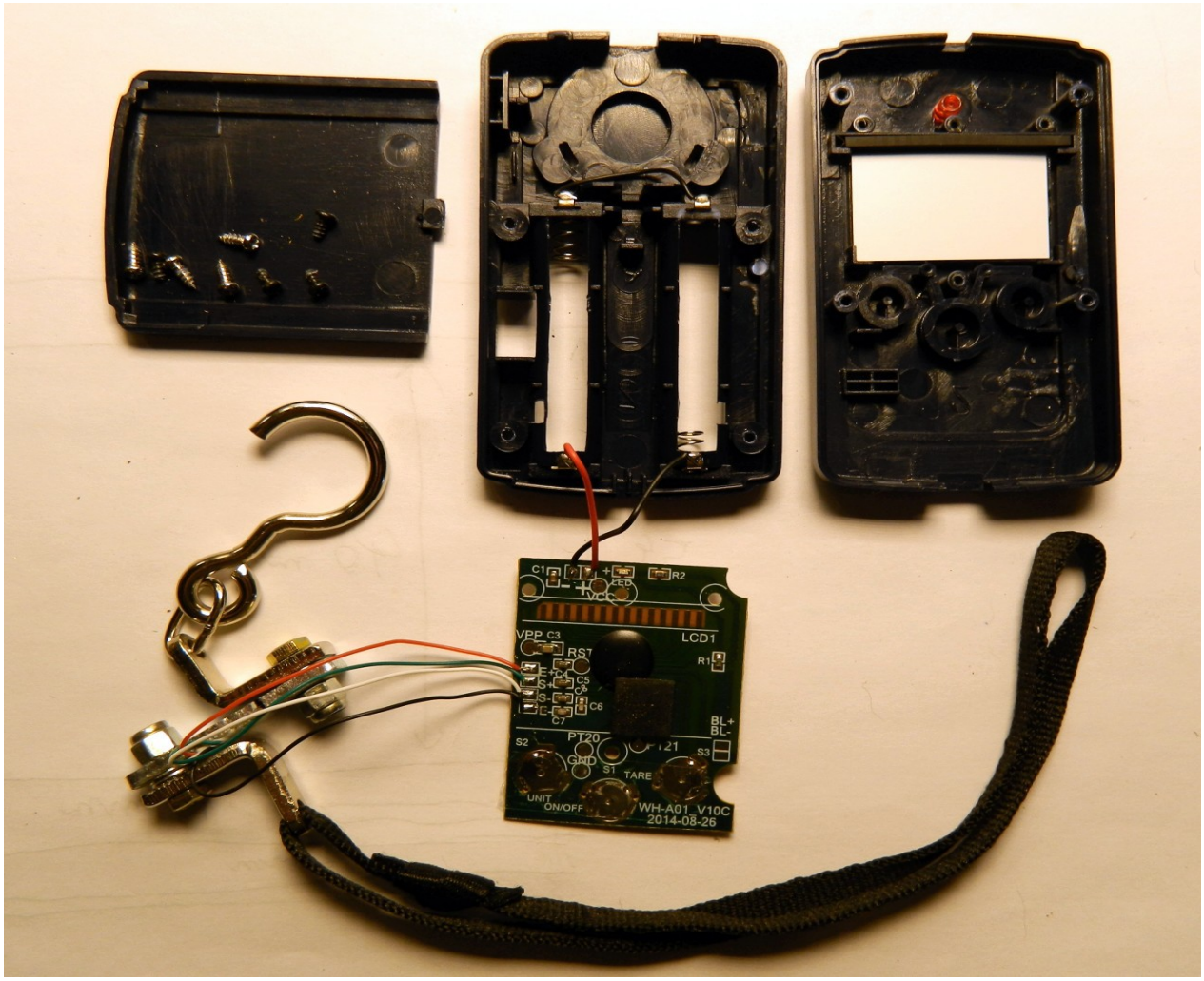
Theremino **System**



Connect load cells to ADC type Pins

It all started from here



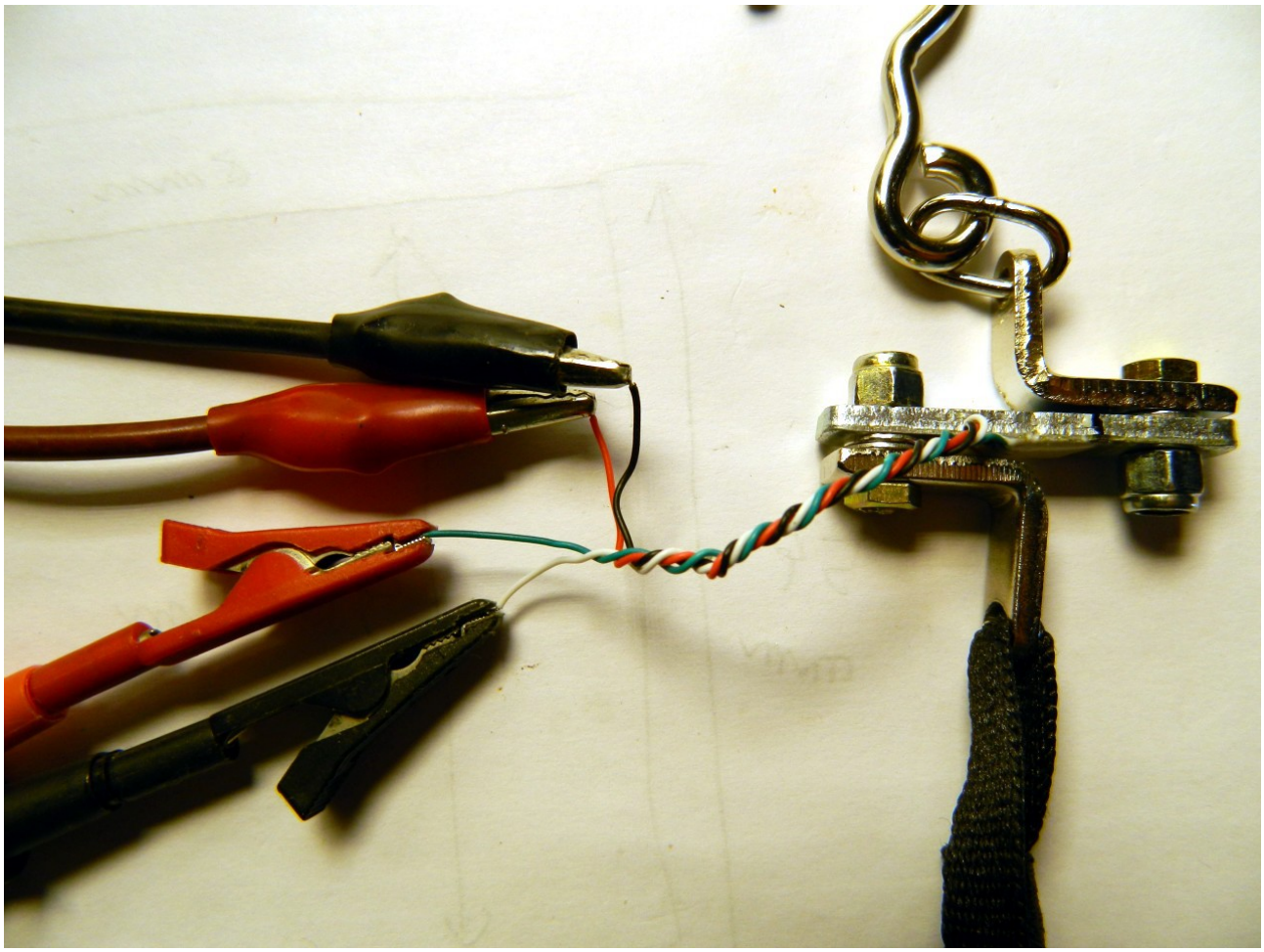
On eBay you can find very cheap load cells, just remove them from the weight scales.

This type of “traction” weight scale, does not need a trapezium to keep aligned the forces, so the mechanism is very simple. Just pull the two sides and everything is aligned automatically.

The declared characteristics of this model are:

- Maximum load: 40 kg
- Accuracy: +/- 10 grams

Measuring the load cell



First of all prepare the wires, curled for extra strength and well skinned, to connect easily to a meter and to a power supply, during measurements.

The results of measurements without load are:

The load cell is a bridge formed by four resistors about 800 ohms each.

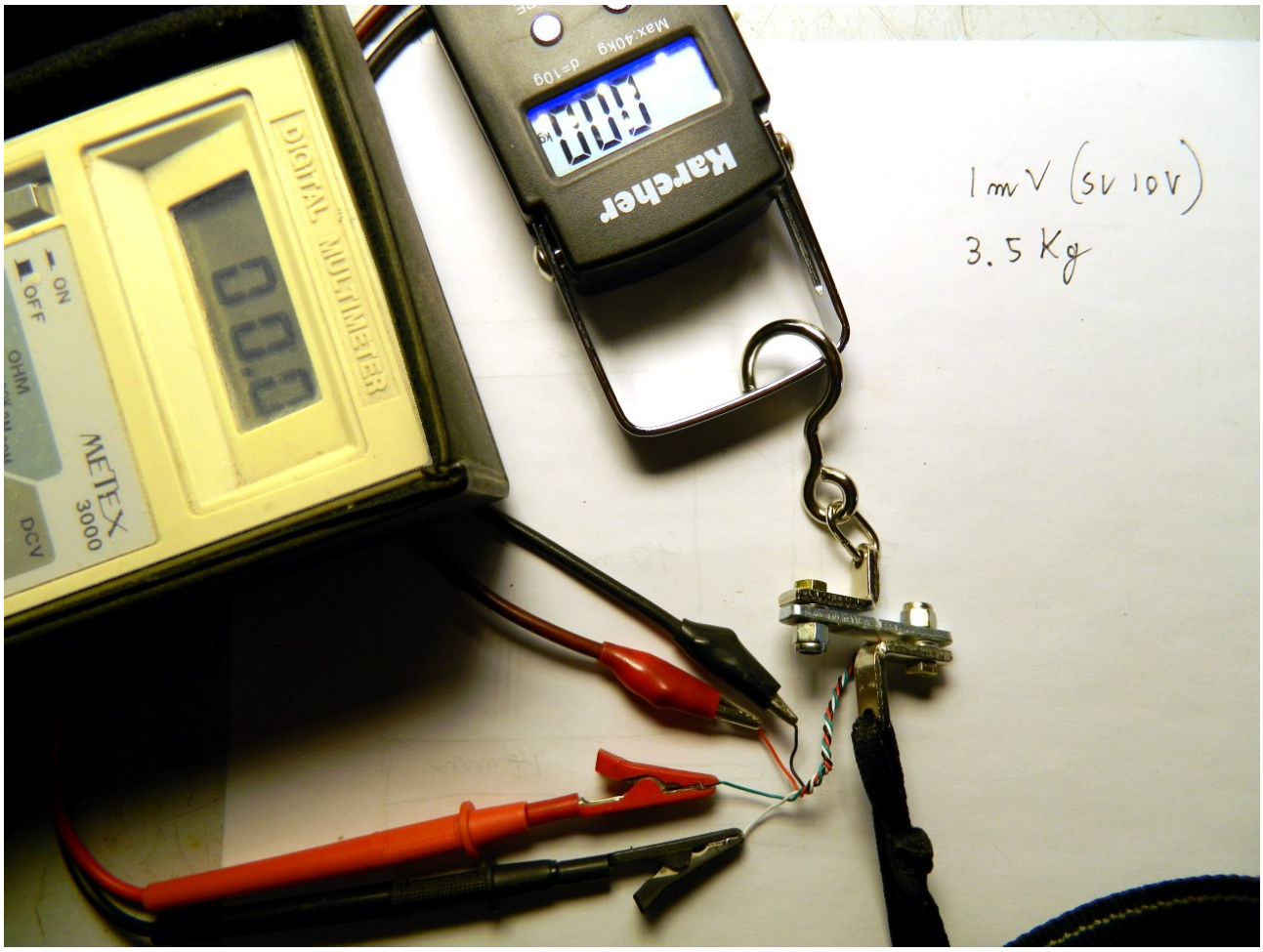
It is fed with the wires black (-) and red (+) with voltage of 1 to 10 volts

- Originally feed with 1 Volt
- You could probably go up to 10 Volt to have more signal

The output is a (weak) voltage between the wires white (-) and green (+).

The output without load is practically zero volts (or low enough not to be measurable).

Measuring the sensitivity to the load



If you feed the cell with 10 volts you can obtain an output voltage of 1 mV with about 3.5 Kg.

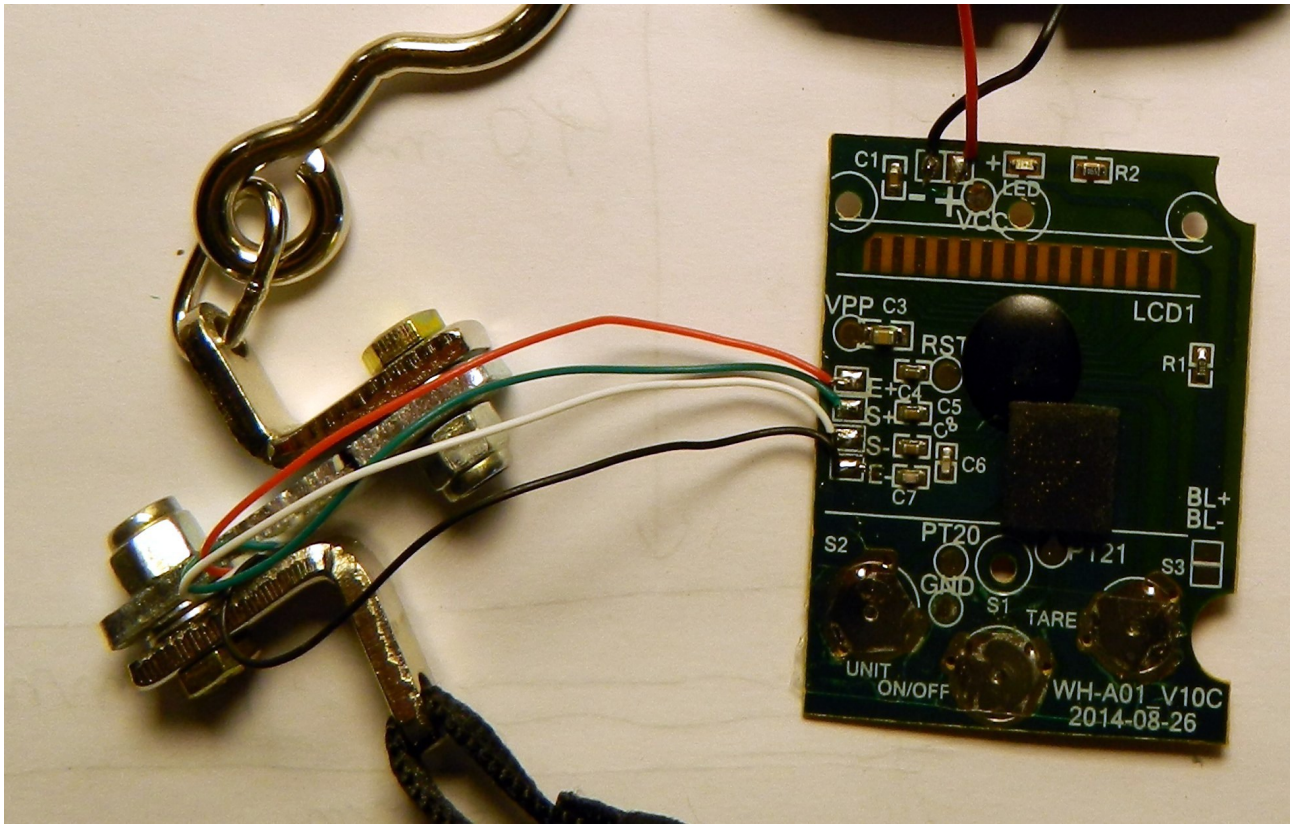
Strength Applied	Output voltage of the cell with different power supplies (With 1 Volt)	(With 3.3 Volt)	(With 10 Volt)
1 g	0.029 uV	0.094 uV	0.286 uV
10 g	0.286 uV	0.944 uV	2.860 uV
100 g	0.003 mV	0.009 mV	0.029 mV
1 Kg	0.029 mV	0.094 mV	0.286 mV
10 Kg	0.286 mV	0.944 mV	2.860 mV
40 Kg	1.144 mV	3.775 mV	11.440 mV

Assessment of achievable accuracy

With forces of 10 grams or less, the value of the signal is in the order of nanovolt, so it is not measurable with accuracy, with no technique humanly reasonable.

The accuracy of 10 grams has been obtained with an integrated circuit specifically designed for these equipment, it is definitely stabilized in temperature and likely it has inside a linearization table, calculated for this specific cell.

However, it is declared to have an accuracy of +/- 10 grams, achievable only if the temperature does not change much and if the “reset” has been done before.



Exploiting the already present circuitry

Read the digital data would require:

- Find a point from which to extract the digital value (which seems not to be present).
- Feed the PCB of the equipment.
- Add an additional PCB with a PIC to decode the serial data.
- Develop a firmware for the PIC which can decode the digital signal.
- Find a way to avoid the need to press the button manually every few seconds.

Searching with the oscilloscope there seems not to be a point where you extract the signal, the whole thing is complicated by the fact that the cell is supplied only for a moment and that every time you have to press again the small button.

Read the value that goes on display would require:

- Connect wires to all segments (15 wires - pretty horrible as a solution)
- Add an additional PCB with a PIC to decode the data from 7-segment numeric value.
- Develop a firmware for the PIC which can decode the digital signal.
- Find a way to avoid the need to press the button manually every few seconds.

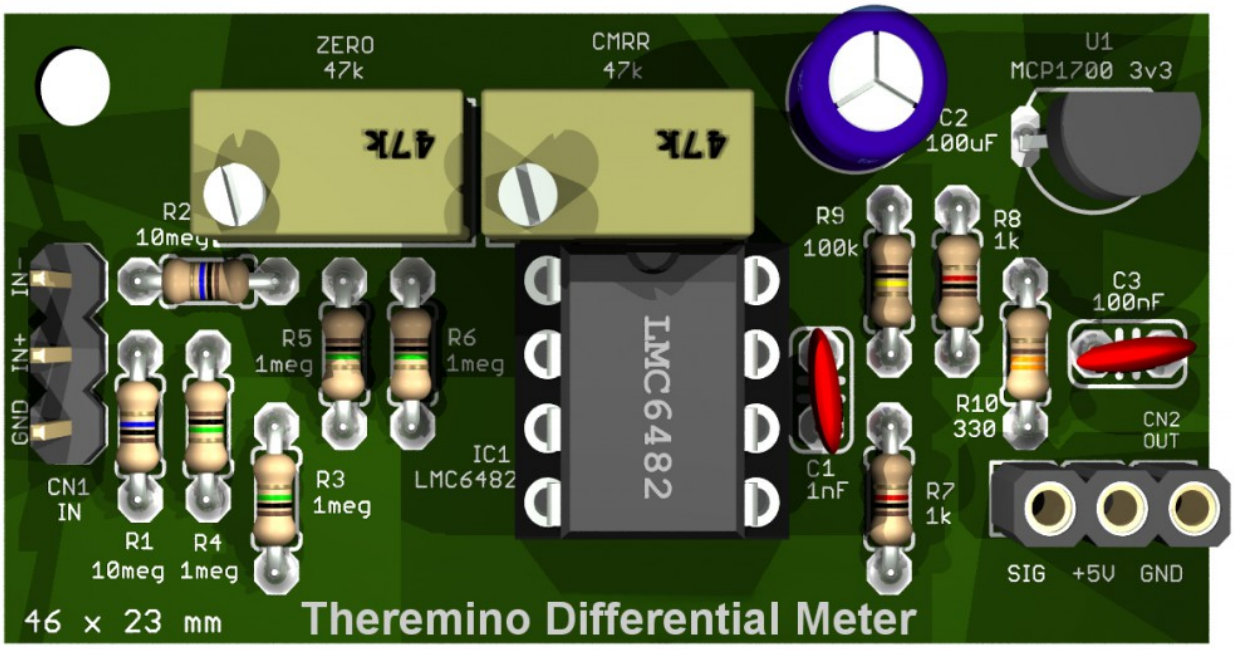
Conclusion

Exploiting the integrated circuit already present appears complex, uncomfortable and so inelegant, that we refuse to proceed in this direction. Who wants to try ...

Directly connect the cell to an ADC Pin

Connecting the load cell directly to a Pin barely you might appreciate the +/- 10Kg.
No comment!

Accuracy with a Diff Meter



Reading a load cell with a generic module such as our Diff Meter, will not give an accuracy of +/- 10g.

Supplying the cell with 3.3 volts, ten grams are about a MICRO Volt, thus we can exclude definitely to be able to read accurately.

Or better, the accuracy would be obtained but not the stability.

The measure should be done immediately after calibration. If the temperature changes after calibration the measure will not be accurate.

With a perfect calibration and the choice of the most appropriate scale, one could reasonably expect to achieve an accuracy around +/- 100 grams, but only practical tests will say that you can really get steady measures.

Connecting the cell to the Diff Meter

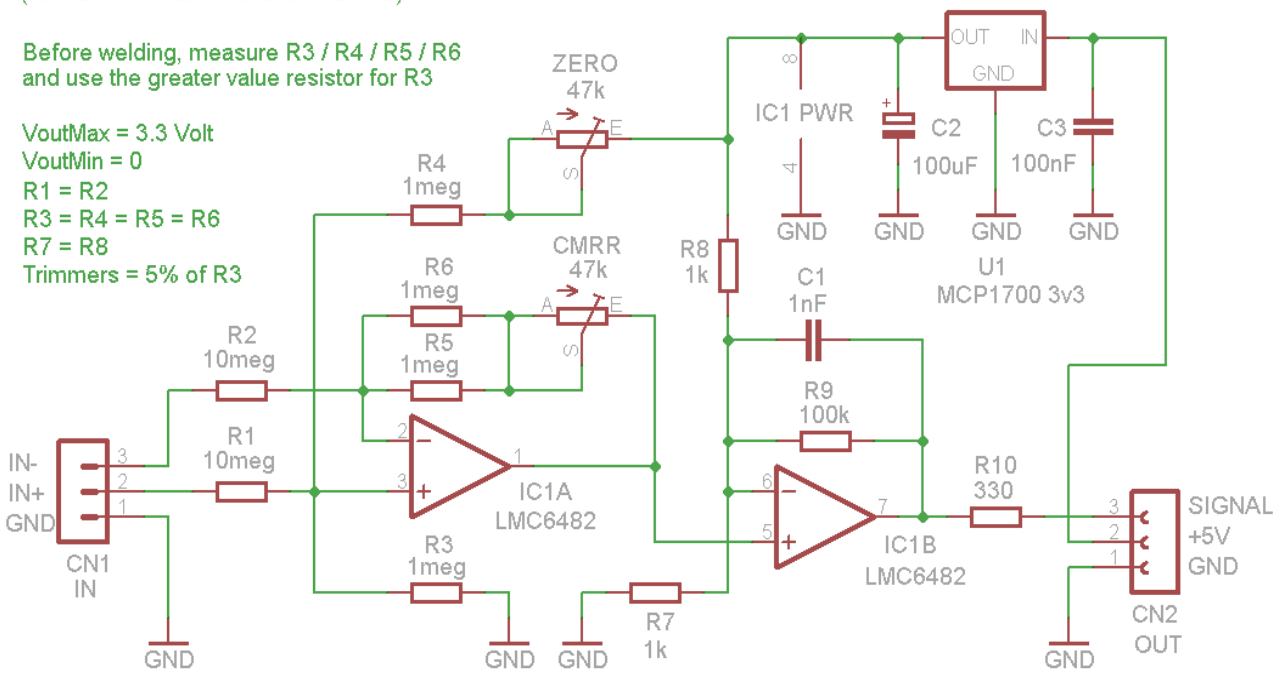
Theremino - Differential Meter

Trimming:
1) Short IN+ with IN- and trim ZERO
2) Short IN+ and IN- with GND and trim CMRR
(trim for 1.65 Vout or 500 on the HAL)

Gain = (R3 / R1) * (1 + 2 * R9 / R8)
Max common mode voltage = 3.3 * R1 / R3
Max differential voltage = 3.3 / Gain

Before welding, measure R3 / R4 / R5 / R6
and use the greater value resistor for R3

VoutMax = 3.3 Volt
VoutMin = 0
R1 = R2
R3 = R4 = R5 = R6
R7 = R8
Trimmers = 5% of R3



The cell is to be connected in this way:

- The black wire is connected to GND (close to IN + and IN-) and the red wire to + 3.3Volt stabilized.
- The white connects to IN- and green to IN+

The Diff Meter must be configured as shown, except that:

- R7 = R8 = 10K
- R1 = R2 = 100K
- The trimmer CMRR could be eliminated (with a jumper)

These are initial values. To have greater sensitivity you could further lower R1 and R2.

Calibrate the zero level
Without input signal the pre-amplifier has an output value of 1.65 volts, thus a software value of 500 and the software will do the reset from this value.

But since the measures are only in one direction (with load always pulling), it could be possible to calibrate the zero very low (almost zero volts), so as to obtain a greater range of measurement and be able to amplify higher values without saturating, and so to achieve a better accuracy.

To calibrate the zero at the bottom level you have to rise R4 and trim the calibration (for example, 100mV output) with the trimmer ZERO.

Connect load cells to ADC 24

Forget all the previous pages, this is the right solution!

A Theremino Adc24 module can read up to 8 scales, one hundred times per second. The load cells can be connected directly, without any additional hardware and without trimmers to be regulated.

Connections to the Adc24 are:

- Black wire to GND
- Red wire to + 3.3 Volts stabilized.
- White wire to differential input (reference)
- Green wire to differential input (signal)

On the left a 0.01 to 100 gram scale, in the center a 0.1 to 500 grams, at the right a load cell from a "pull" 40 Kg Scale. All for sale on eBay for about 5 Euros, and all containing a load cell with four wires.

By connecting the load cells of these balances to an Adc24, you get the following features:

Jewelry scales

- Full scale from 100 to 500 grams
- Resolution 0.1 milligrams.
- Accuracy and repeatability around 1 ... 10 milligrams.

Kitchen scales

- Full scale from 1 to 5 Kg
- Resolution 10 milligrams.
- Accuracy and repeatability around 100 milligrams.

“Pull” scales:

- Full scale 40 Kg
- Resolution 0.1 grams.
- Accuracy and repeatability around 1 gram.

The advantages compared to balances that you buy on eBay, are to be able to connect to a PC, and do more than 100 measurements per second.

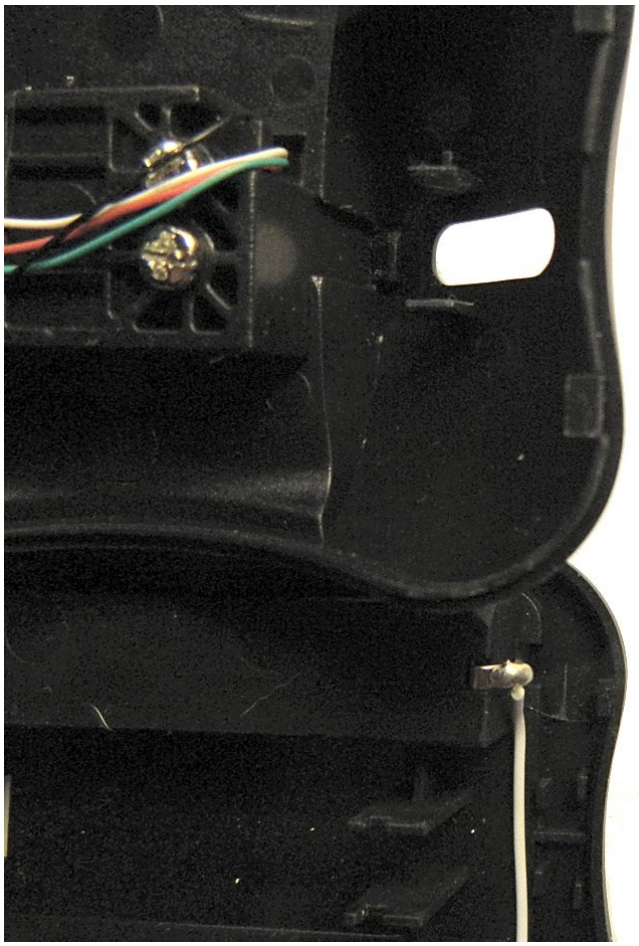
How to modify a precision scale

This Mouse shaped scale is selling on eBay for around eight euros, shipping included. We recommend it as a base, because it has many advantages:

Opens easily by removing two screws, without straining the plastic, and is mechanically robust.
Once opened all is easily accessible.
Contains a very precise, and mechanically stable, load cell.
The interior spaces seem made for the change we need to do.
The hole for the wheel is great for getting the connector without pierce the container.
If desired, you can restore the original behavior in five minutes.

You start by removing the batteries and by removing the two screws.

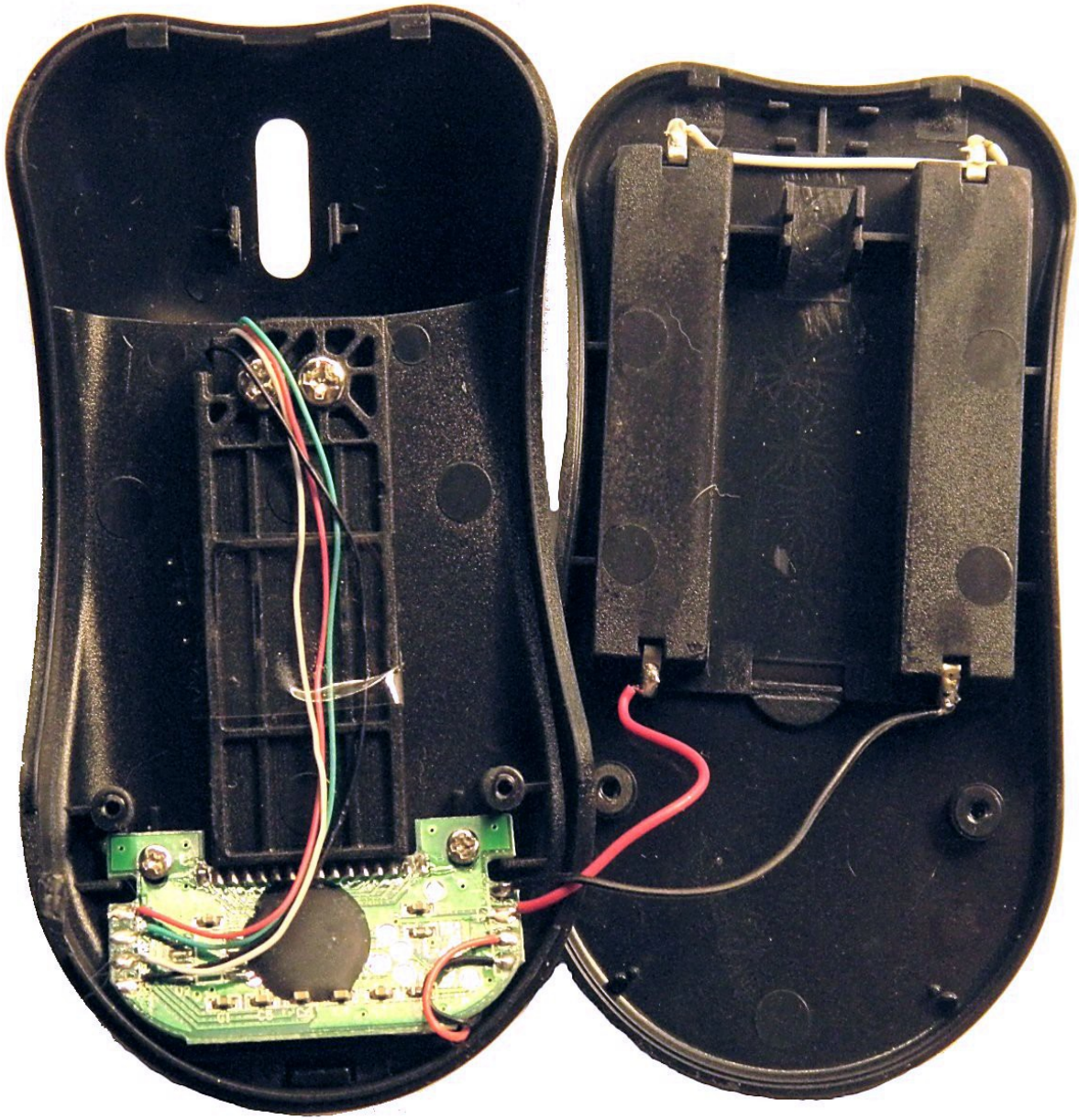
All the necessary components are a piece of strip-board (28 x 9 mm), and a four-pin male connector.



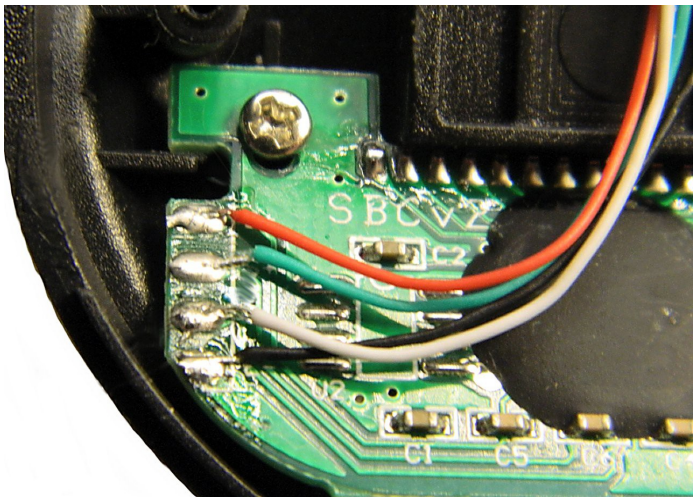
1) **Weld the connector on the plate center.**

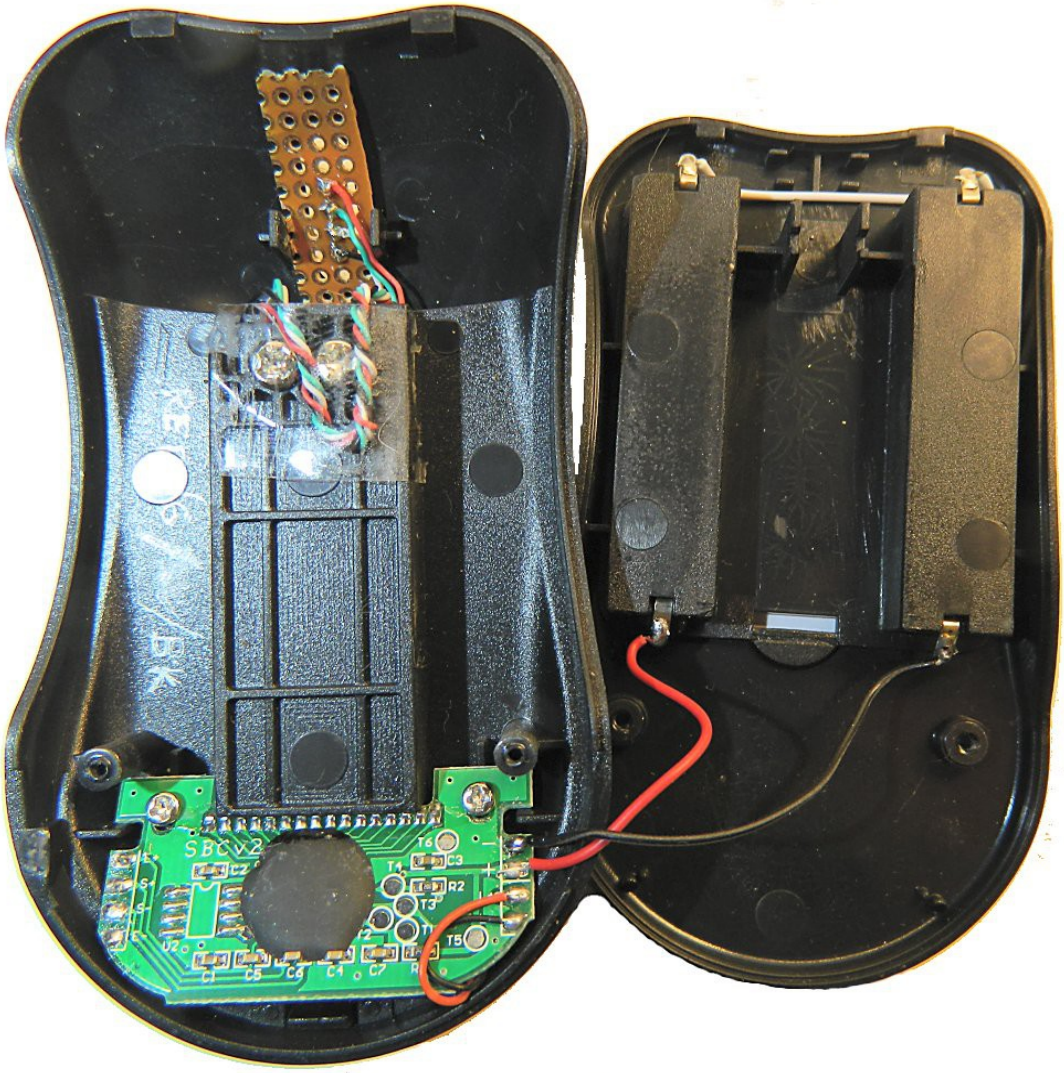
2) **Cut the long points with the Clippers.**

3) **The fake mouse wheel is taken off and the plate is put in its place.**

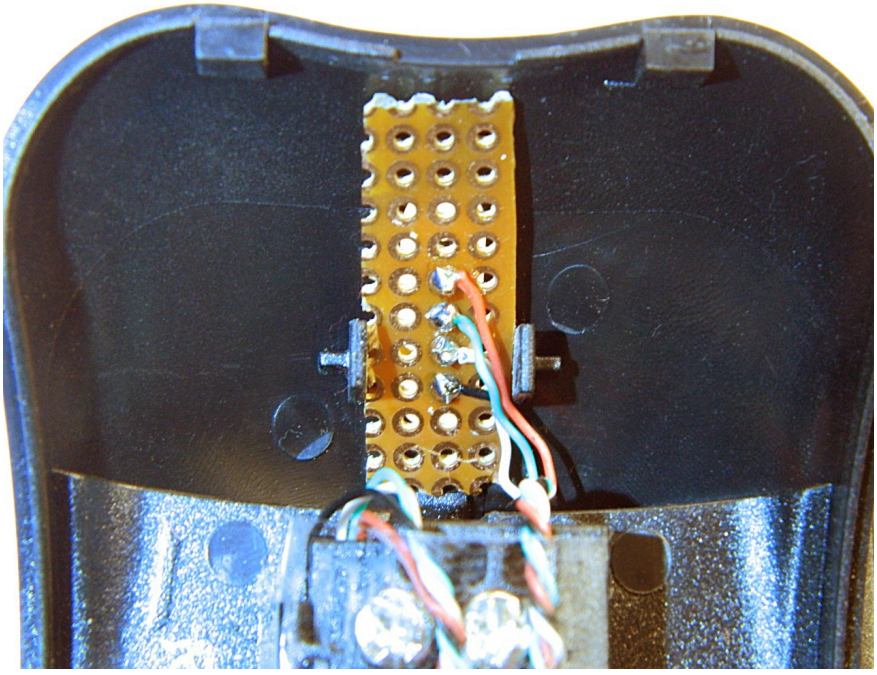


Those are the connections before...





And those are the connections after the modification.



The finished scale has its tray protective cover, and a connector for the female-female ADC connection wires.

The four wires are:

- **+ 3.3 Volt**
- **Negative differential signal**
- **Positive differential signal**
- **GND**

The four wires are directly connected to a differential channel of the Theremino ADC24 board and read with the application Theremino Balance.

If the measure goes in the negative direction then reverse the order of the four wires.