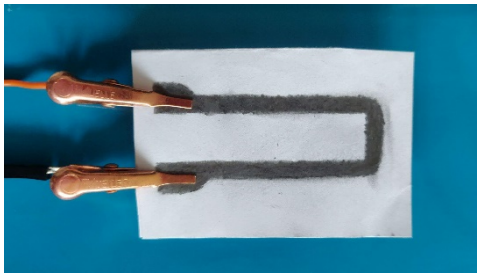
Flex graphite sensor

General features



- Low power consumption
- Easy-to-use
- Small size
- Low cost
- Short response time
- Easy to bend up to 180°
- Very high sensitivity

General description

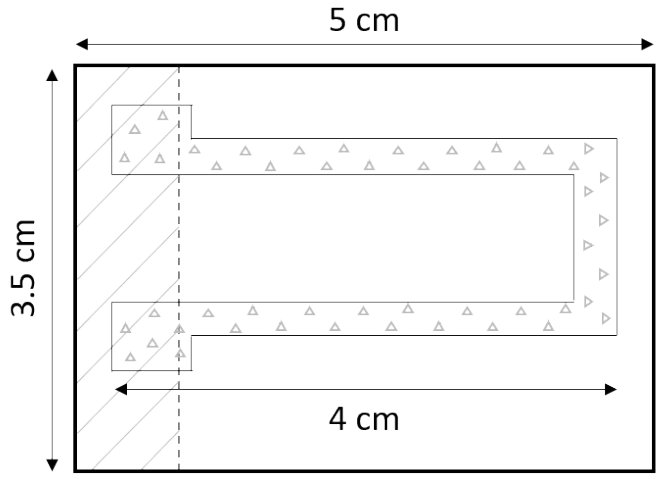
This project was initiated after the publication of Pencil Drawn Strain Gauges and Chemiresistors on Paper[1] which showed that strain gauges could be made out of a piece of paper and a pencil. Indeed, the pencil deposits graphite particles on the paper that allow for some current to go through the drawing. Electrons move from one particle to the other using tunnel effect. Because of how very sensitive tunnel effect is to distance of the tunnel, compressing or stretching the graphite changes widely its resistivity. The paper gauge is subjected to such tension or compression when it is deflected downwards or upwards respectively. Using this change of resistivity coupled to an amplification circuit allows the paper to be used as a strain gauge. The circuit is also linked to an OLED screen to help the calibration and then to show how much the paper is strained. The Nunchuk is here to choose the calibrated value for the digital potentiometer. Then, the resistance of the strain gauge is sent to an Android app thanks to a Bluetooth module.

Specifications

Type	Strain Sensor, passive
Materials	Graphite (B pencil), paper and metal clips (to link it to the circuit)
Power supply	5 V
Output signal	Analog
Measurand	Voltage
Response time	< 20 ms
Maximum curvature radius	75 mm

[1] Lin, C.-W., Zhao, Z., Kim, J. & Huang, J. Pencil Drawn Strain Gauges and Chemiresistors on Paper. Sci. Rep. 4, 3812; DOI:10.1038/srep03812 (2014)

Dimensions



Caption:

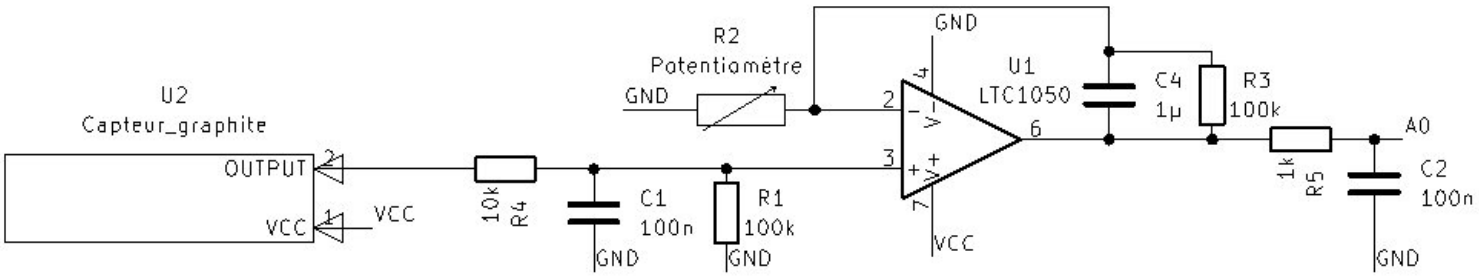
- 0.20 mm width zone
- 0.10 mm width zone
- graphite zone

A second layer of paper is added where the alligator clips make contact for it to be better. The graphite drawing is not centred on the paper to allow for someone to grab it from one side without touching the graphite.

Electrical characteristics

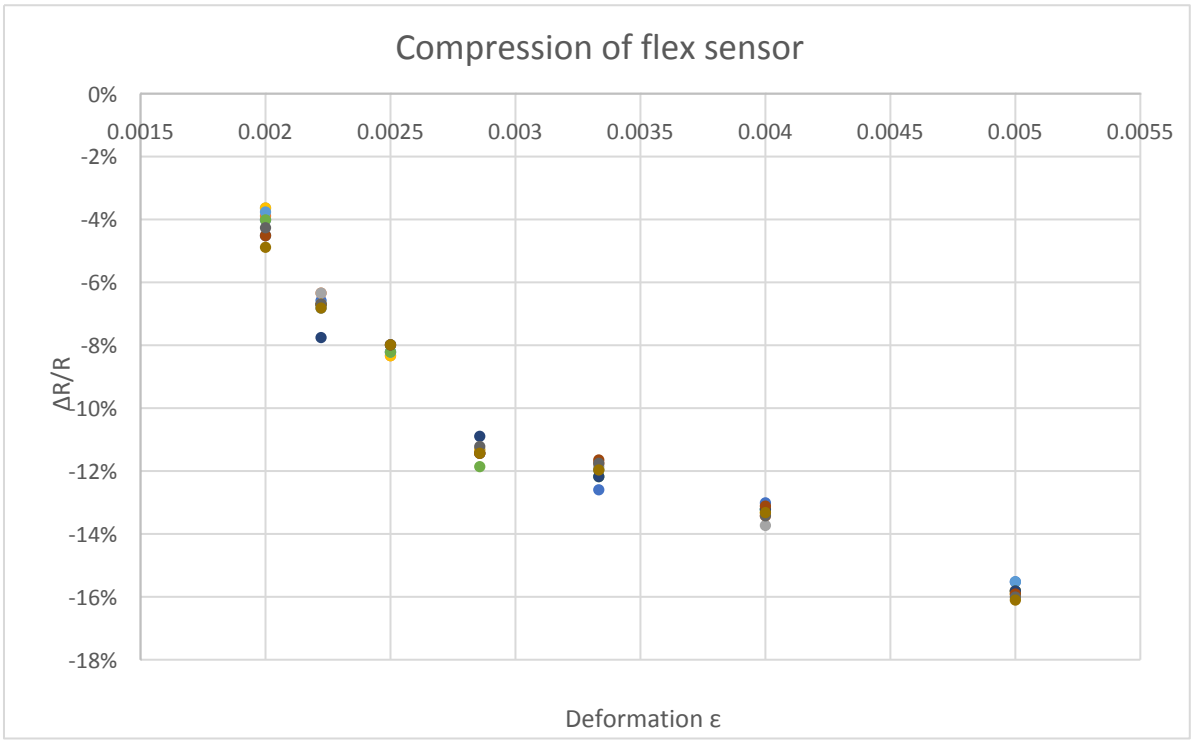
	Minimum	Typical	Maximum	Unit
Resistance	8.5	10.4	14.3	MΩ

Amplification circuit

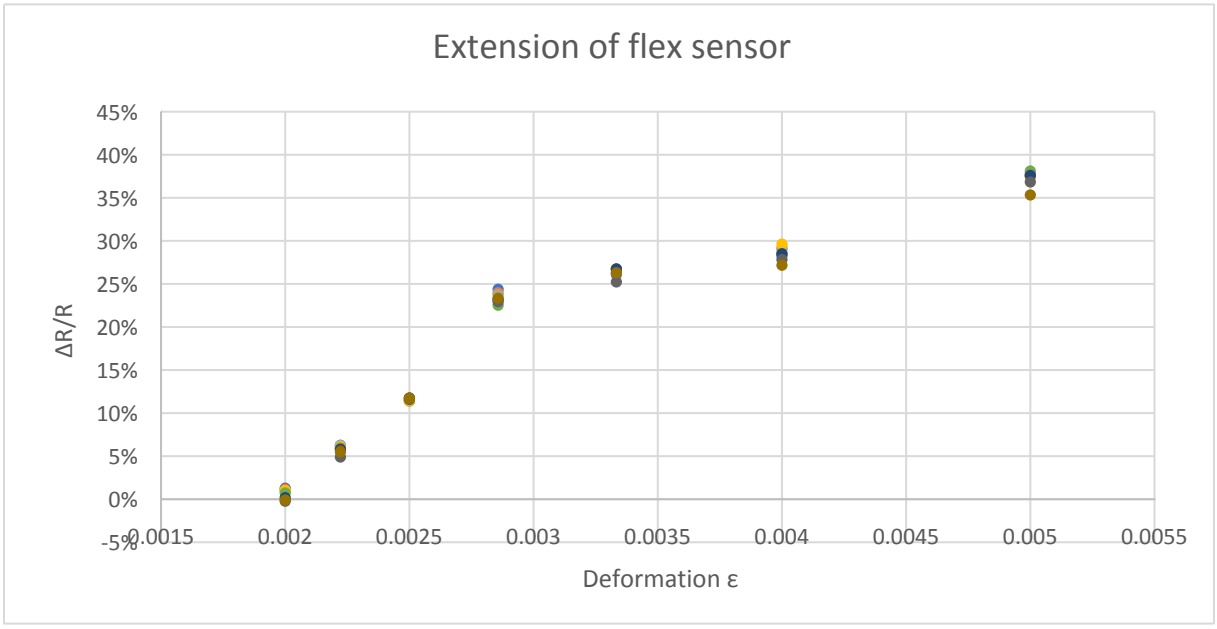


This is the circuit used to amplify the signal and damper the noise. A digital potentiometer is used to maximise the response of the sensor. Thanks to an OLED screen and a Nunchuk the user can change it to the value wanted in the range allowed by the potentiometer.

Flex graphite sensor characteristics



Both graphs show the change in resistance of the sensor for ten measurements as a function of the deformation. Each trend line is based on the average resistance for each deformation.



Beware, it is difficult to have constant results. Indeed, even with the most care, graphite is very sensitive to any contact with fingers, the alligator clips or even the test bench that was used.