Low-tech graphite strain sensor

Main features :

- Low cost
- Low power consumption (3.3V – 3.5V)
- Small size (< 10 cm^2)
- Ultra-light (10g)
- Easily reparable

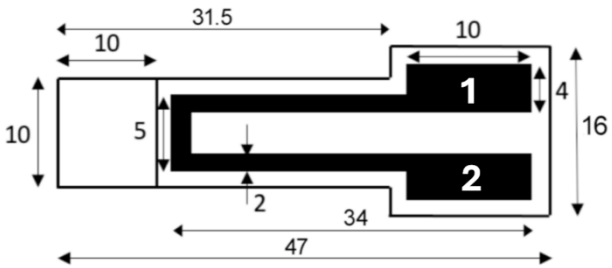
General description :

This low-tech strain sensor was developed in the Engineering Physics Department at INSA Toulouse. It is inspired by the article "*Pencil Drawn Strain Gauges and Chemiresistors on Paper*" by Cheng-Wei Lin, Zhibo Zhao, Jaemyung Kim and Jiaxing Huang, published in 2014.

This sensor operates on a simple principle :when the paper is deformed, the number of connected graphite particles (from pencil traces) changes. This variation is directly correlated with the type of deformation, resulting in a measurable change in electrical resistance and conductance. This phenomenon enables the sensor to function similarly to a traditional flex sensor.

The structure of the graphite layer depends on the type of pencil used. We tested four types of pencil : 6B, 4B, B and HB, ranging from hardest to softest. For the tests, the sensors were connected to a transimpedance amplifier and an Arduino Uno, all mounted on a PCB.

Dimensional diagram :



Pin nimber	Typical voltage
1	V_{in}
2	V_{cc}*

*Typically, a +5 V voltage

Ratings :

Total supply voltage : 5V

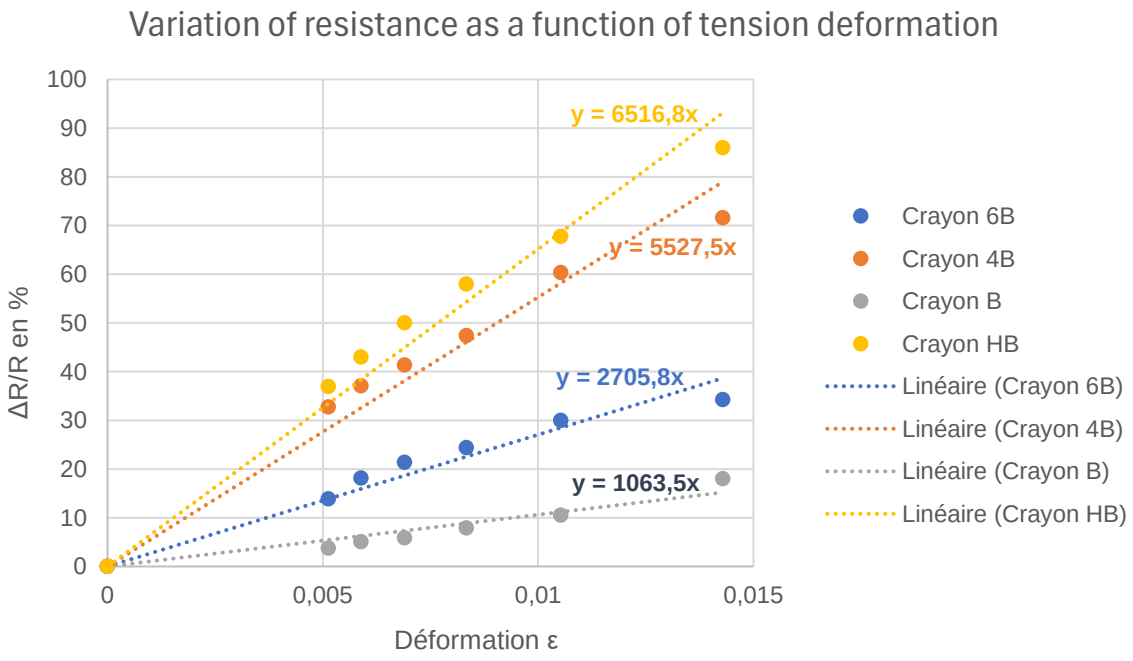
Temperature : .....10°C to 30°C

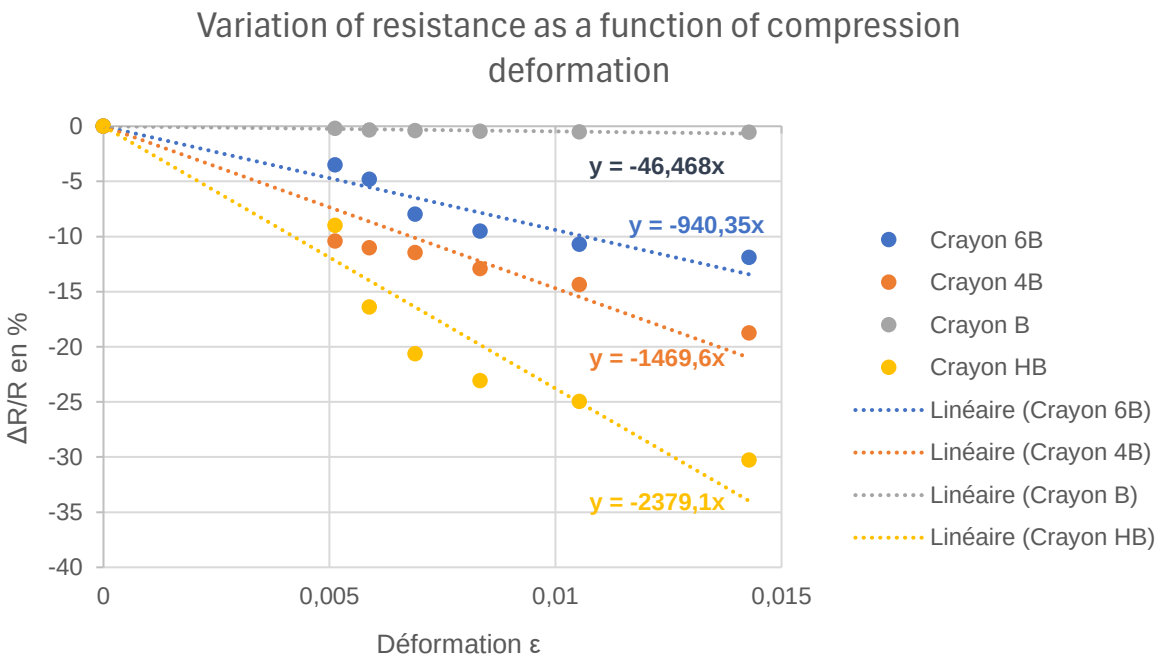
Humidity : ..... 20% to 80%

Electrical characteristics :

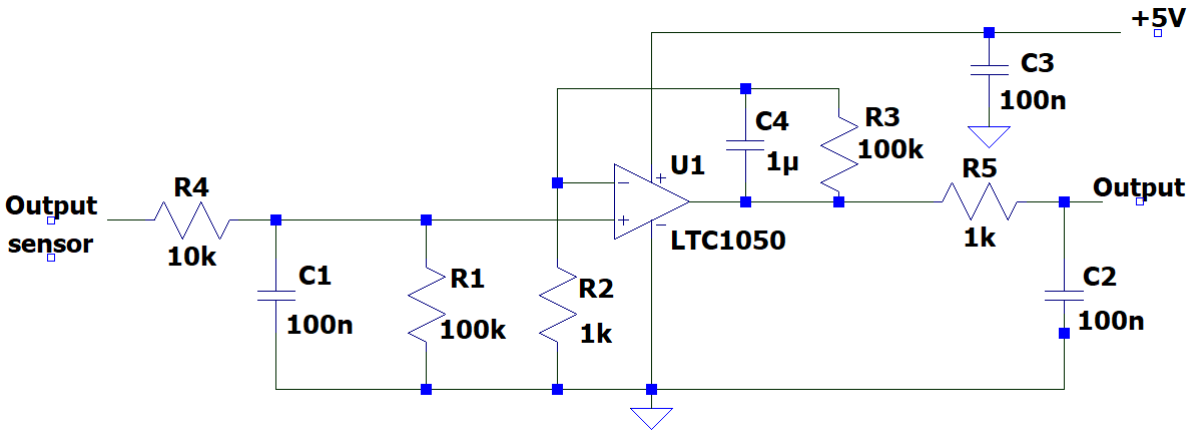
Parameter	Unit	Value		
		Min	Typical	Max
Power supply	V	-	5	-
6B	MΩ	0,08	0,09	0,13
4B	MΩ	0,3	0,5	1
B	MΩ	5	5,4	7
HB	MΩ	50	200	450

Typical performance characteristics :





Typical application :



The sensor is connected to a transimpedance amplifier circuit in order to produce a signal readable by the Arduino Uno. A combination of low-pass and high-pass filters removes noise generated by amplification, the current and the 50 Hz component from the electric network.

The resistor R2 can be replaced by a variable resistor. It us used to adjust the amplification of the circuit to suit each pencil type.

The resistance value can be determined using the following formula :

$$R_{sensor} = R_1 \left(1 + \frac{R_3}{R_{variable}}\right) \frac{V_{cc}}{V_{adc}} - R_1 - R_5$$