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LOW-TECH GRAPHITE-BASED STRAIN SENSOR

GENERAL FEATURES :

- Strain sensor
- Easy-to-use
- Low cost
- Environmental-friendly
- Low tech
- Low cost

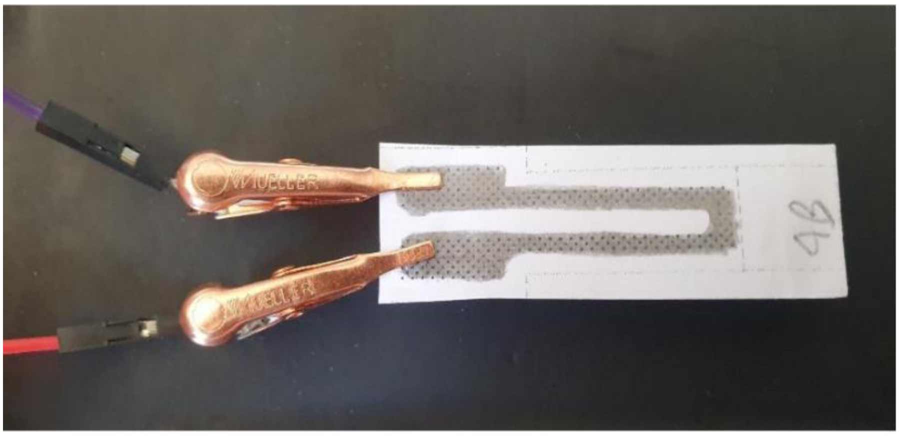


Figure 1: Strain sensor

GENERAL DESCRIPTION

This train sensor based on Graphite particles and paper was developed in Physics Lab of National Institute of Applied Sciences. This low-tech sensor is made from a piece of paper on which we applied graphite thanks to various types of pencils. This sensor allows to measure a variation of resistance according to the bending radius of the sheet of paper.

The graphite coating being made of numerous graphene layers, there is a dependance between the electrical conductivity and the average mean free path between the particles. By modifying the shape of the paper sheet, we are changing of the graphite layer and thus the inner resistance of the sensor.

Different types of pencils have been used to make the sensor (2HB, 1B, 4B), we are giving here their characteristics.

We used an Arduino board paired with a PCB including a transimpedance amplifier. We also designed an interface to display the sensor values, on an app and an OLED screen.

Specifications

Type	Strain Sensor
Sensor Type	Passive – *need power supply*
Materials	– Metal Clips – Paper – Graphite Coating (HB, 1B, 4B)
Nature of Output Signals	Analog
Measurand	Voltage
Power Supply	+5V
Typical Application	Deformation evaluation (Compressive/Tensile deflection)
Response Time	<500 ms

Dimensions

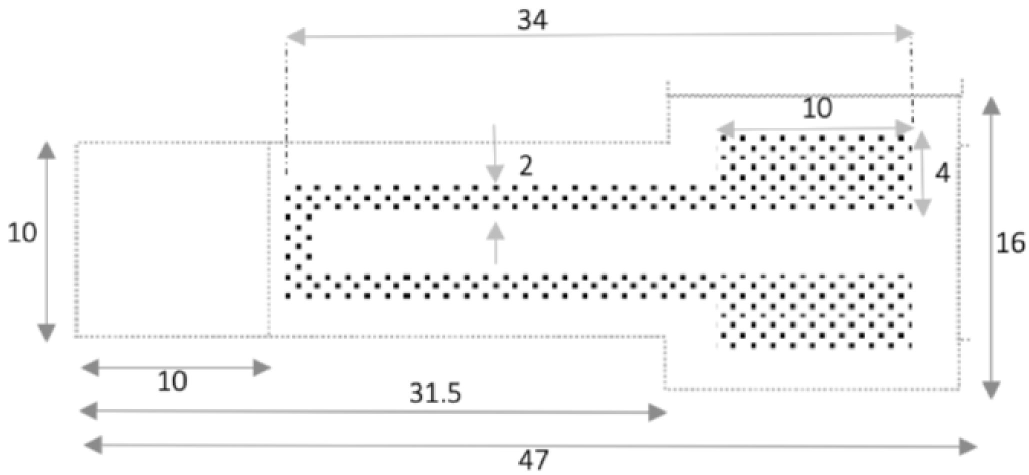


Figure 2: Sensor Scheme Top-view (dim. in mm)

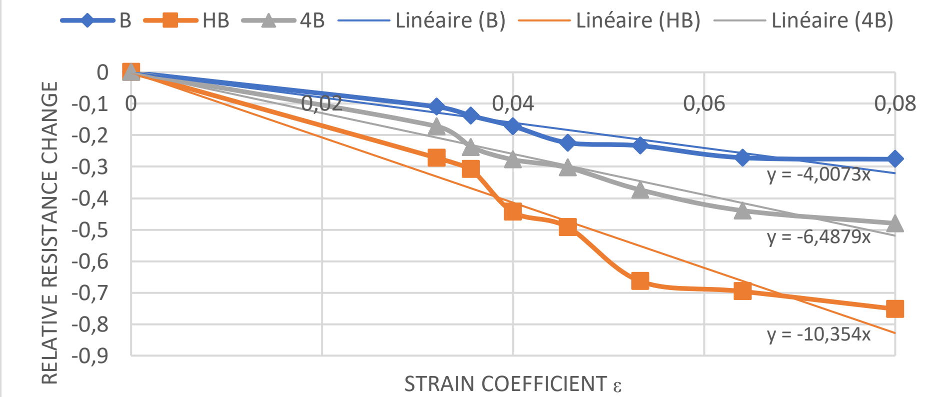
Standard Operating Conditions

The sensor was used at room temperature around 20±5°C at 60±10% humidity rate with a pressure of 1atm.

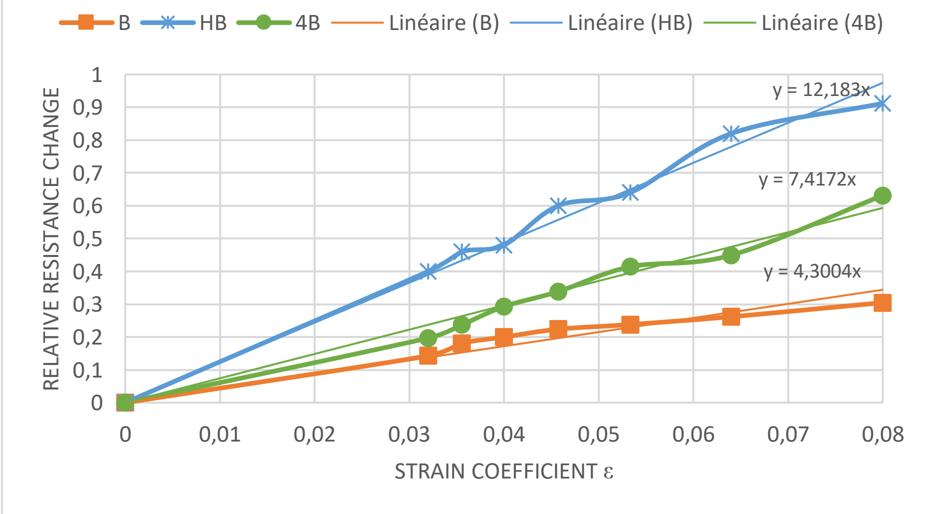
Electrical Characteristics

	Unit	Value		
		Min.	Typical	Max.
HB Pencil	MΩ	12,4	50	95,6
1B Pencil	MΩ	15,2	21	27,4
4B Pencil	MΩ	103	198	323

Strain Sensor Characteristics



CHANGE IN RESISTANCE (NORMALIZED) UNDER COMPRESSIVE DEFLECTION FOR DIFFERENT PENCIL HARDNESSES



CHANGE IN RESISTANCE (NORMALIZED) UNDER TENSILE DEFLECTION FOR DIFFERENT PENCIL HARDNESSES

TYPICAL APPLICATION

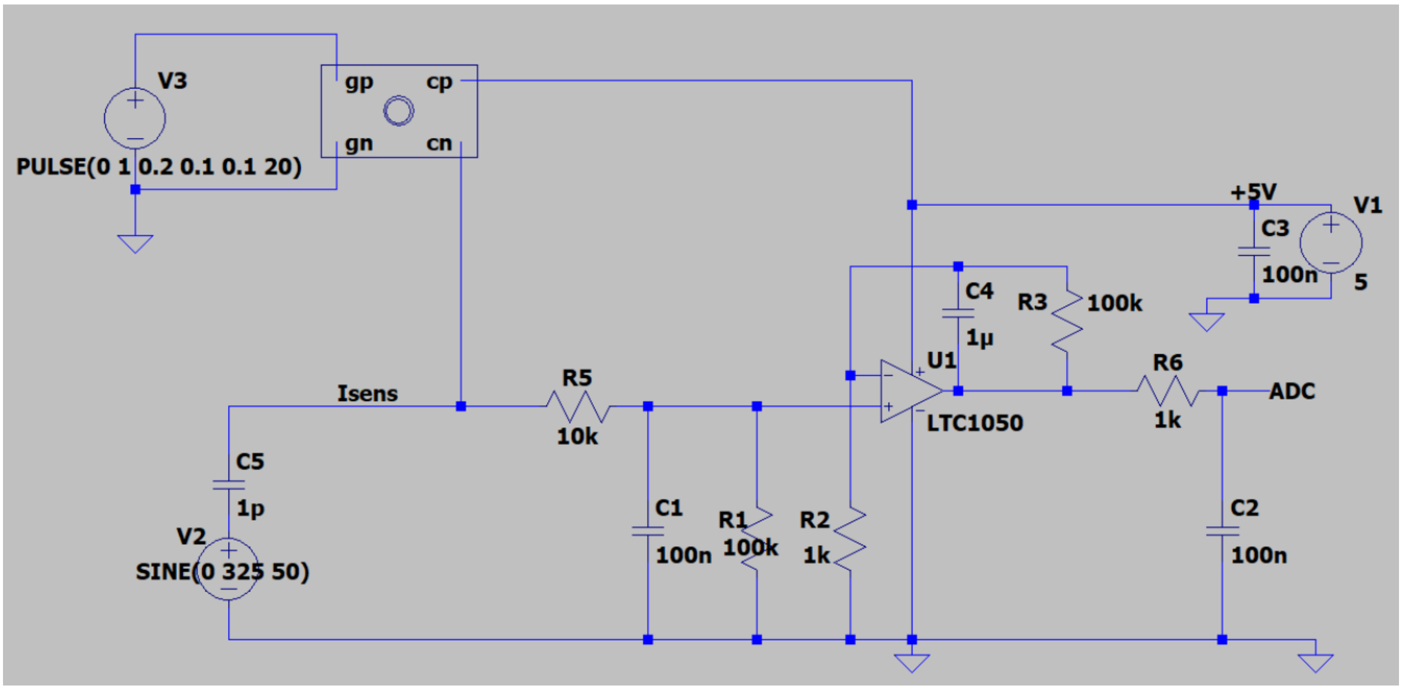


Figure 3: Transimpedance amplifier circuit to use the sensor.

The sensor is connected to a transimpedance amplifier circuit with low and high pass filters.

The low-pass filters are used to get read of spurious signal coming from the sensor and the high-pass filter is here to cancel the 50Hz defect on the signal.

The resulting voltage can then be connected to a 5V ADC such as an Arduino board. The assembly presented above avoids an excess of noise at the input of the ADC, which could bring it to saturation. From the voltage value V_{read} on the Arduino board, it is possible to recover the resistance value of the sensor with the formula below: At low frequencies, we have:

$$R_{sensor} = \left(1 + \frac{R_3}{R_2}\right) \cdot \frac{R_1 \cdot V_{cc}}{\frac{5}{1023} \cdot V_{read}} - R_1 - R_5$$