Low-tech graphite-based strain sensor (C)

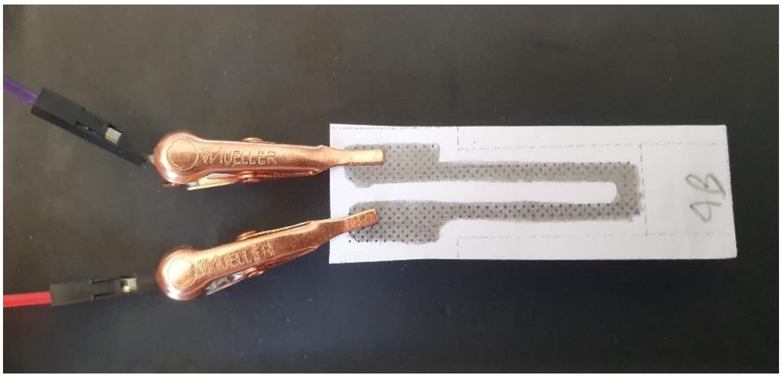


Figure 1: Stain Sensor SYCC00

Main features

- Strain sensor
- Low cost
- Low tech
- Low power consumption
- Intuitive app
- Easy-to-use

General description

This strain sensor based on graphite (C) particules and paper was developed in Physics Lab of Institut National of Applied Sciences. This low-tech sensor is made of a piece of paper, in which we apply graphite using a pencil. Used in the same experimental condition, this sensor allows to measure a variation of resistance, and thus a relative variation of voltage, according to the bending radius of the sensor.

When we apply a compression strain on the sensor so that carbon atoms are closer, the current flows more easily: the resistance decreases. In return, when we apply a tension deformation on the sensor, the measured resistance increases.

We used different types of pencils (B, 4B, 6B, 9B, HB, 2H) and measured the variation of resistances for each of them as a function of the radius of curvature. The variation of resistance of the sensor decreases as the pencil used is greasy.

A PCB shield including the sensor was created and built. It is coupled to an analog circuit, that was designed to interface the strain sensor. This one communicates data via a microcontroller to an Android application developed on the website "*MIT App Inventor*".

Spécifications

SYCC00

Type	Strain Sensor
Sensor type	Active sensor – *Power supply requirement*
Materials	▪ Graphite (2H, H, HB, B, 4B, 6B, 9B pencils) ▪ Paper ▪ Metal pliers
Nature of output signals	Analog
Nature of measurands	Resistance
Dimensions	▪ Length: L = 35 mm ▪ Width: Ls = 5 mm ; Lb = 15 mm
Mean Sensibility	▪ 2H : S1 = 0,1418 cm^{-1} ▪ 9B : S2 = 0,1596 cm^{-1}
Typical application	Deformation evaluation (compression strain or tension deformation)

Dimensions

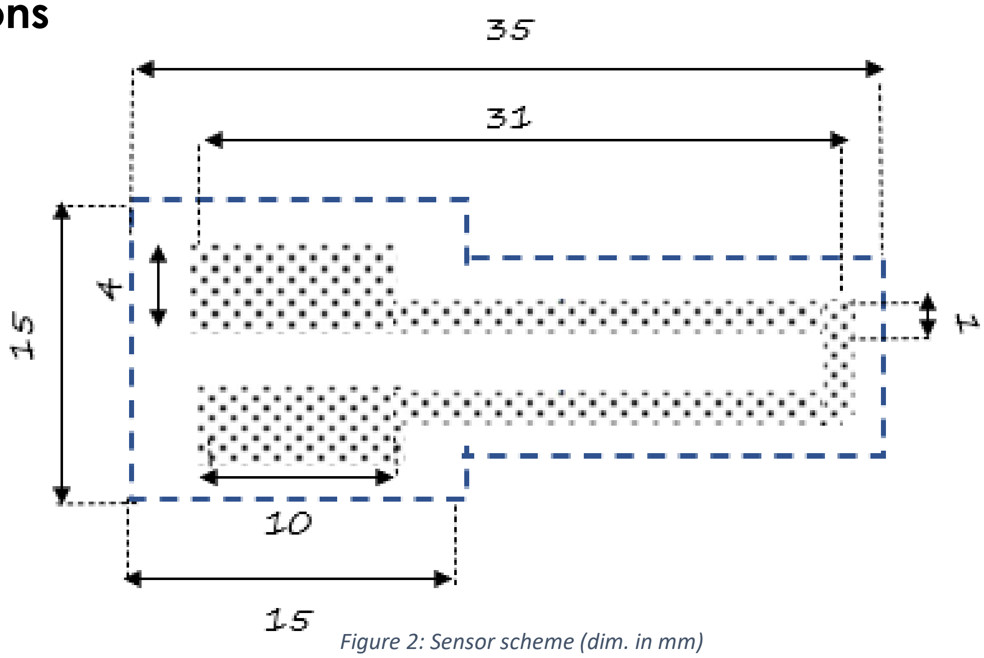


Figure 2: Sensor scheme (dim. in mm)

The dotted part corresponds to the one to be coloured with graphite. Two pliers are placed at the two left ends. One of the pliers must be connected to a power supply. The other allows to read the current value.

Standard use conditions

We use this sensor at ambient air temperature and pressure.

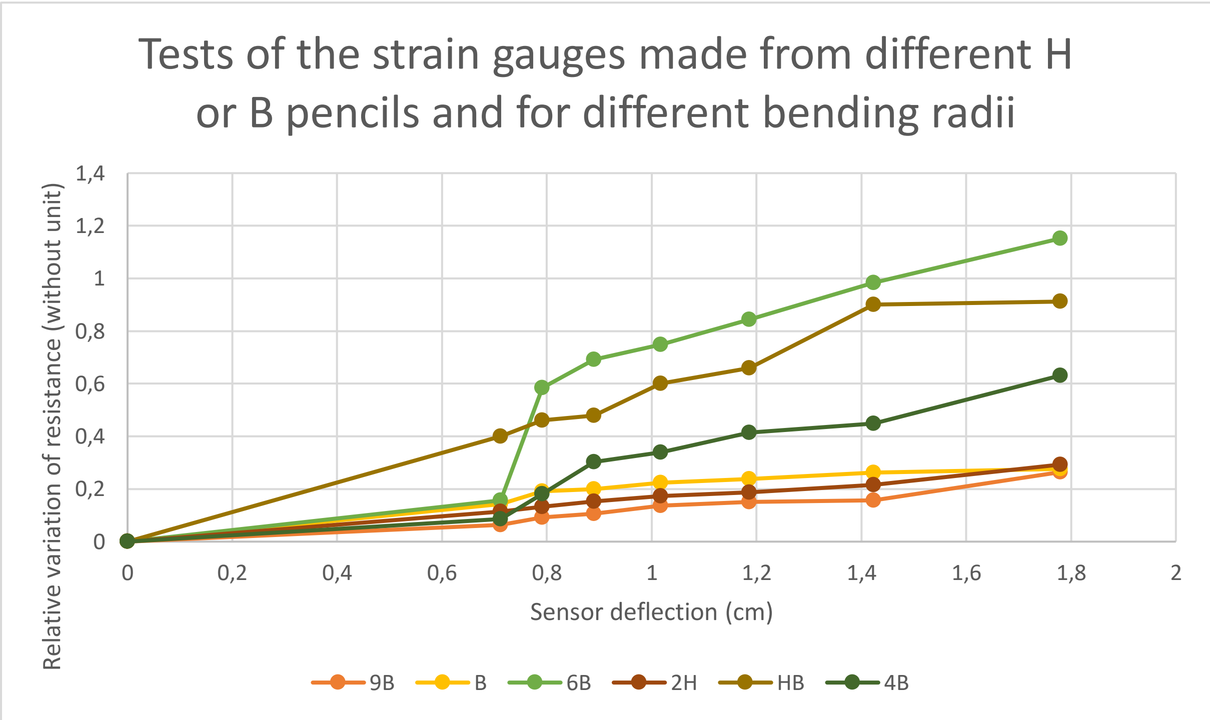
Air quality	80% of N_2 ; 20% of O_2
Temperature	25°C ± 3°c
Pressure	1013 hPa
Moisture	60 ±5 %

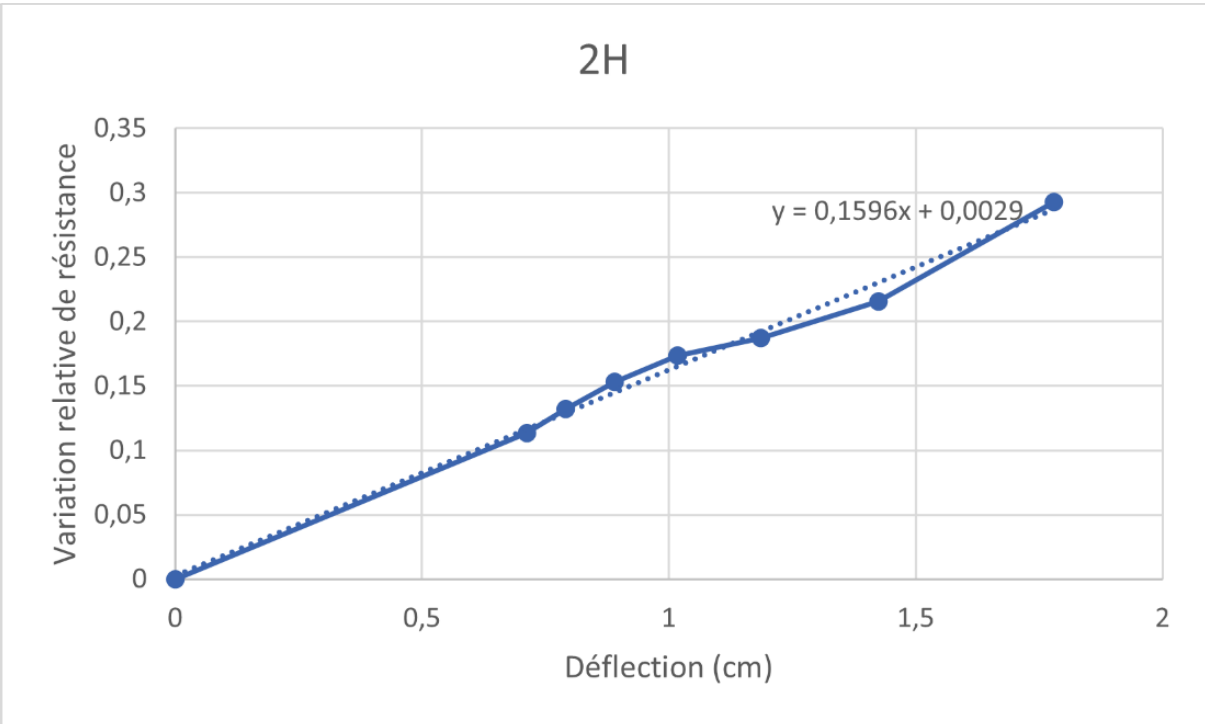
Electrical characteristics

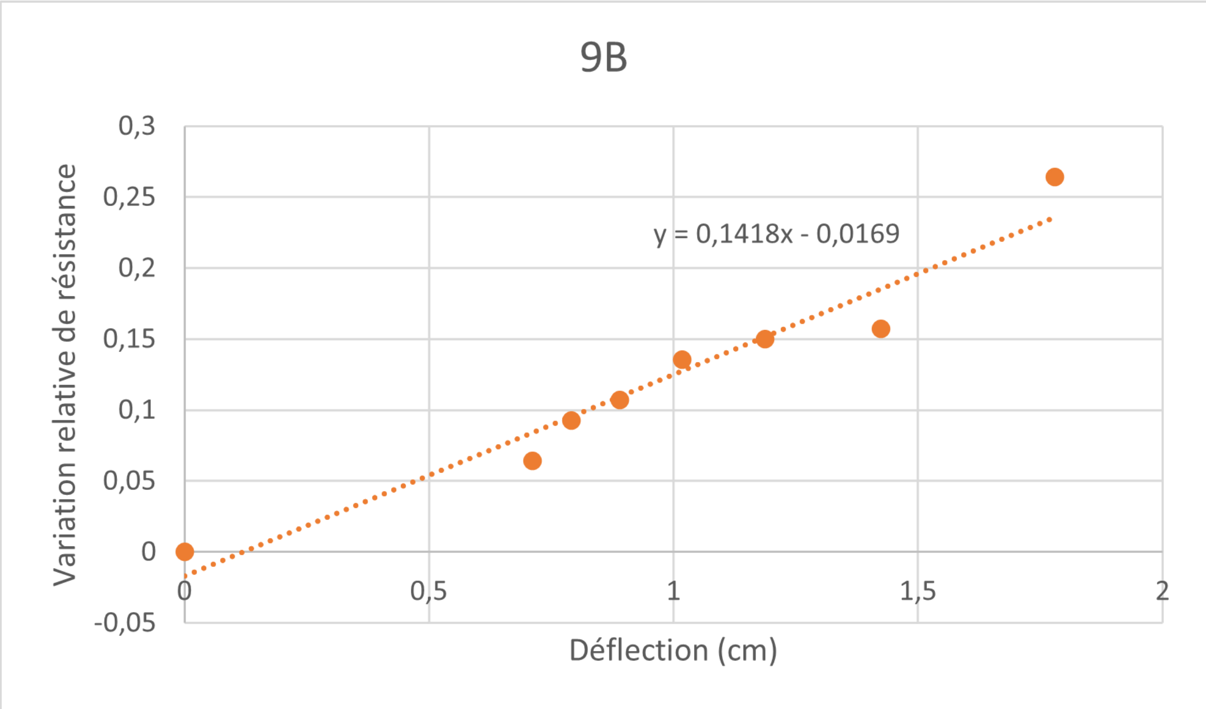
The impedance of the sensor depends on the pencil used and the radii of curvature.

		2H	**HB**	**B**	**4B**	**6B**	**9B**
		R (MΩ)	R (MΩ)	R (MΩ)	R (MΩ)	R (MΩ)	R (MΩ)
C0	/	37,9	50	21	198	25	14
C1	2,5	42,2	70	24	215	28,9	14,9
C2	2,25	42,9	73	25	234	39,6	15,3
C3	2	43,7	74	25,2	258	42,3	15,5
C4	1,75	44,47	80	25,7	265	43,7	15,9
C5	1,5	45	83	26	280	46,1	16,1
C6	1,25	46,07	95	26,5	287	49,6	16,2

Strain sensor characteristics






9B
y = 0,1418x - 0,0169
Variation relative de résistance
0,3
0,25
0,2
0,15
0,1
0,05
0
-0,05
0
0,5
1
1,5
2
Déflection (cm)

Typical Application

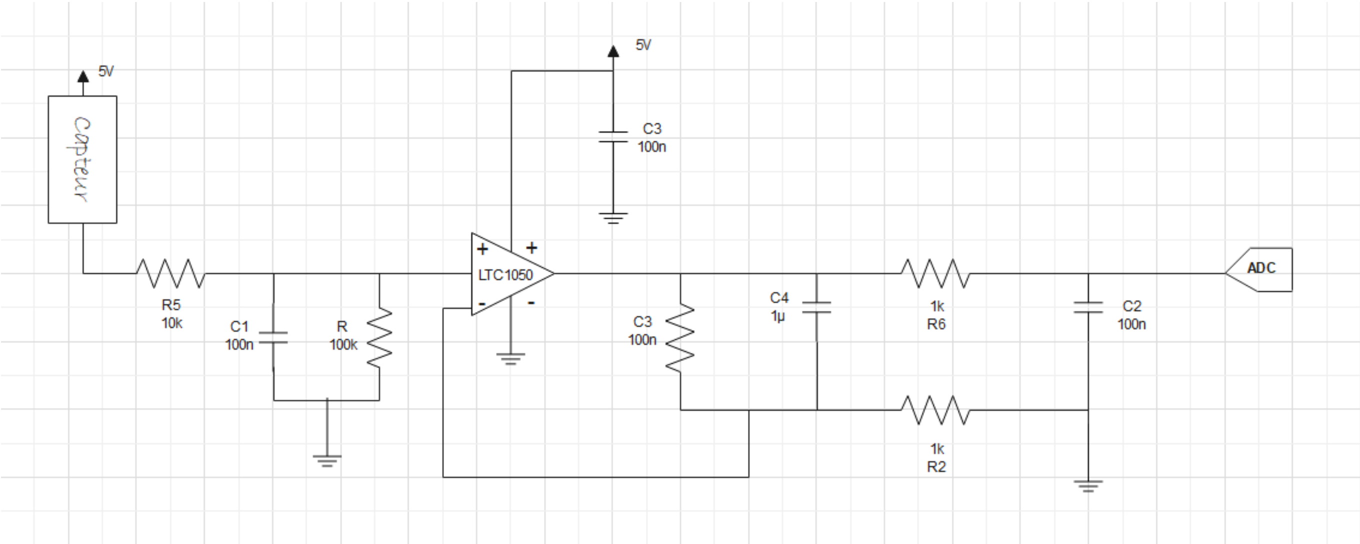


Figure 3: Typical application scheme of strain sensor

The sensor is plugged to a transimpedance circuit, with a low current opamp and low-pass filtering in order to keep only interesting information. The resulting voltage can be read on an ADC (for example, on an Arduino module). Then, we can calculate the resulting resistance from the measured voltage (Vread) on a 5V ADC, 10 bits.

At low frequencies, we have:

$$Rsensor = \left(1 + \frac{R3}{R2}\right) . \frac{R1.Vcc}{\frac{5}{1024}.Vread} - R1 - R5, \qquad with\ Vcc = 5V$$