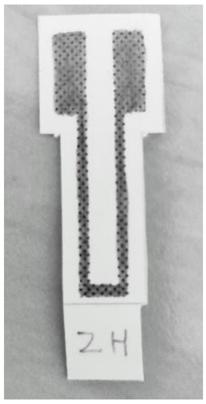
Pencil Drawn Strain Gauges



General features

- Low power consumption
- Easy-to-use
- Small size
- Low cost
- Short response time
- Detection of inward deflection
- Detection of outward deflection

Description

These pencil drawn sensors are usually used as strain gauges. In fact, this sensor is based on electron conduction in films of metal nanoparticles linked by organic molecules modeled by percolation. Standard pencil leads are composed of fine graphite particles held together by clay binders. Based on the hardness of these leads, pencils are classified on a scale from 9B to 9H. The difference in color arises from the different relative fractions of graphite between harder and softer pencil leads. Thanks to this model, inward and outward deflections of the sensor have different effects on the resistance of the pencil trace. Therefore, the two types of deflections are named compressive and tensile deflections,respectively. Sensors are drawn U-shaped patterns connected to two solid rectangles on a piece of office paper. Changes of electrical resistance along the U-shaped trace were monitored using a transimpedance amplifier connected to the electrodes by toothless alligator clips[1].

Specifications

Type	Nanoparticle based sensor
Materials	• Graphite particles • Clay (mainly composed of O, Mg, Al and S)
Sensor Type	Passive
Deflection measurement	Resistive measure
Dimensions	4.7*1.6 cm
Mountig	Toothless alligator clips

[1] Toothless alligator clips's impedance is smaller than the impedance of the sensor : $\underline{Z}_{sensor}$ >> $\underline{Z}_{toothless\ alligator\ clips}$

Standard use condition

	Unit	Typical value
Temperature	°C	20±5
Deflection	mm	from 14 to 43

Electrical characteristics

	Unit	Value		
		Min	Typical	Max
H	MΩ	10,859	20,684	39,000
HB	MΩ	7,407	12,927	29,845
B	MΩ	434	1,044	1,495
2B	MΩ	30.8	45.57	79.9
4B	MΩ	14.28	18.02	21.07

Pencil drawn strain gauge characteristics - measurement procedure

The pencil drawn strain gauge characteristic is determined by measuring the resistance evolution with different deflections. These figures represent the change in normalized resistance in function of pre determined deflections. R_0 is the resistance a gauge has without any deflection applied.

The measurement changes the phenomenon such that the quantity being measured may differ from the measurand. In this case, adequate correction[2] is necessary. This is the reason why the following graphs are representing the relative variation of the sensor's resistivity.
In fact, data are achieved by a reference measurement procedure, whose accepted as providing measurement results fit for their intended use in assessing measurement trueness of measured quantity values obtained from other measurement procedures for quantities of the same kind, or in characterizing reference graphite nanotubes. Then, to fit data: reproducibility condition of measurement in a set of conditions is necessary. That includes different measuring systems, and replicate measurements on the same sensors in order to establish an average value for all deflections.

[2] condition of measurement in a set of conditions that includes the same measurement procedure, same measuring system, same operating conditions and replicate measurements on the same sensors over a short period of time is impossible due to the deformation of the paper, whose interact directly with the perocolation phenomenon.

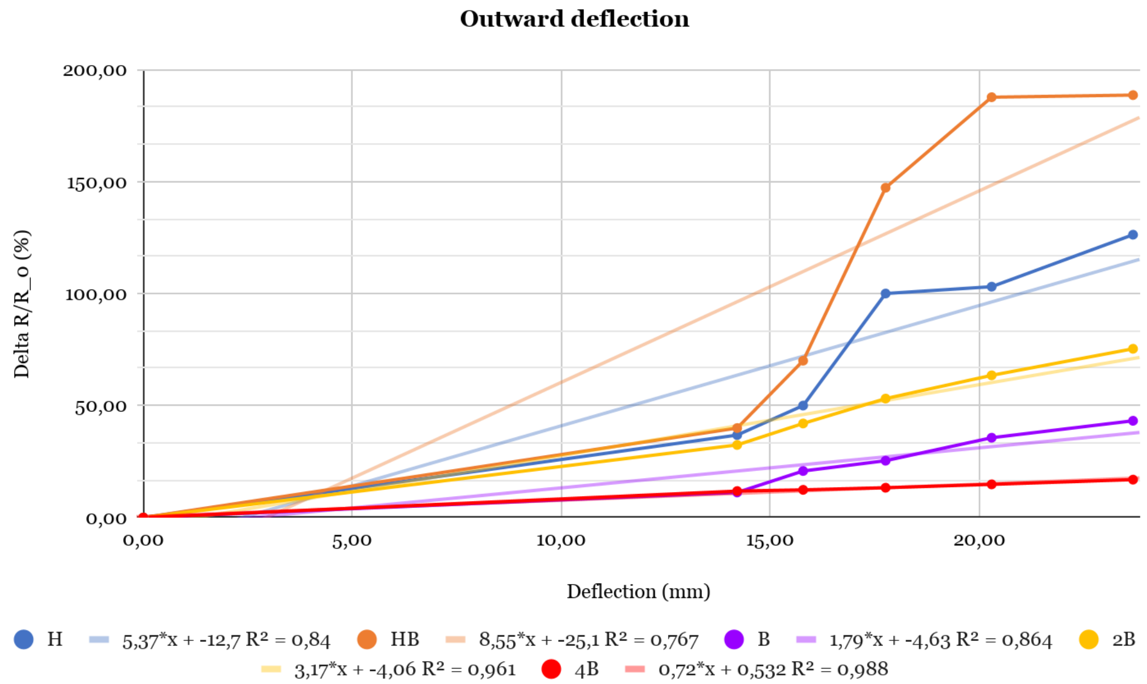


Figure 1: Change in normalized resistance versus deflections for devices drawn with three different types of pencils during compressive mode of deflections.

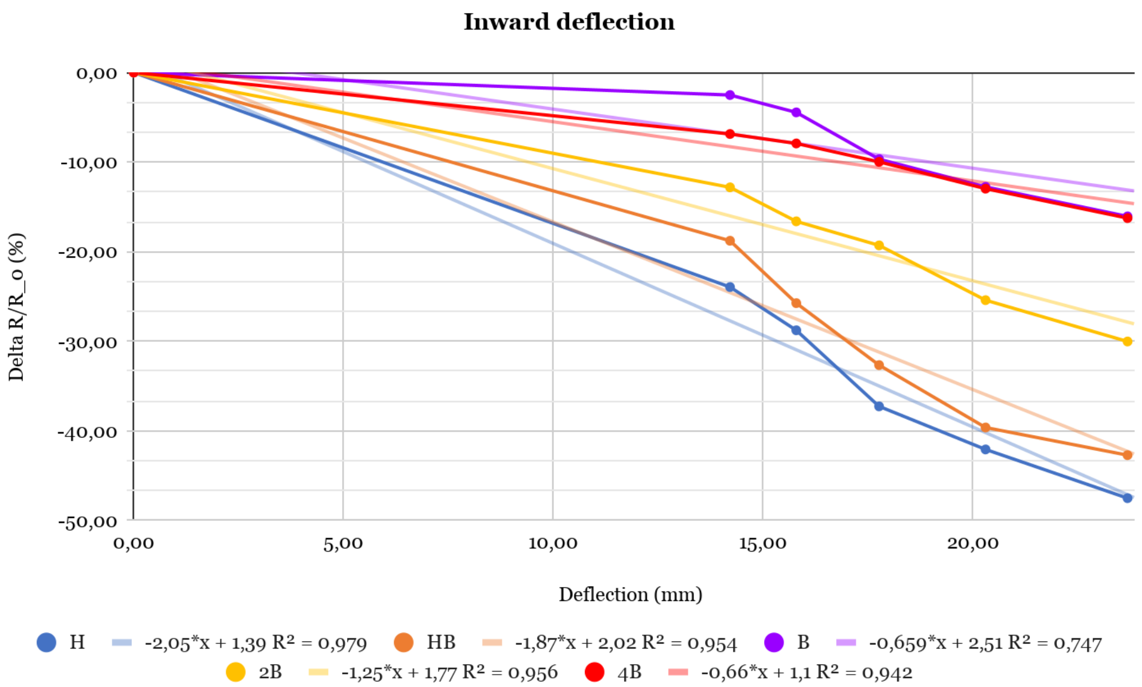
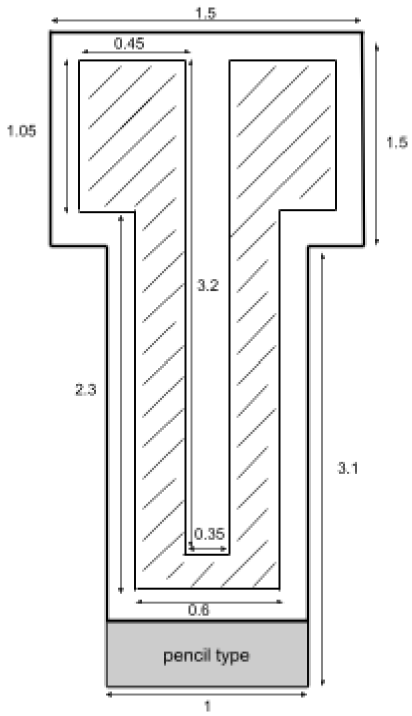


Figure 2: Change in normalized resistance versus deflections for devices drawn with three different types of pencils during tensile mode of deflections.

Dimensions

Sensors are drawn on U-shaped patterns.



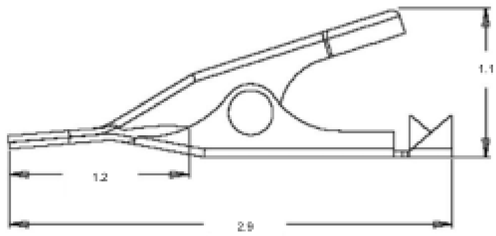


Figure 3: sensor's dimensions (cm)	Figure 4: toothless alligator clips's dimensions (cm)

Typical Applications

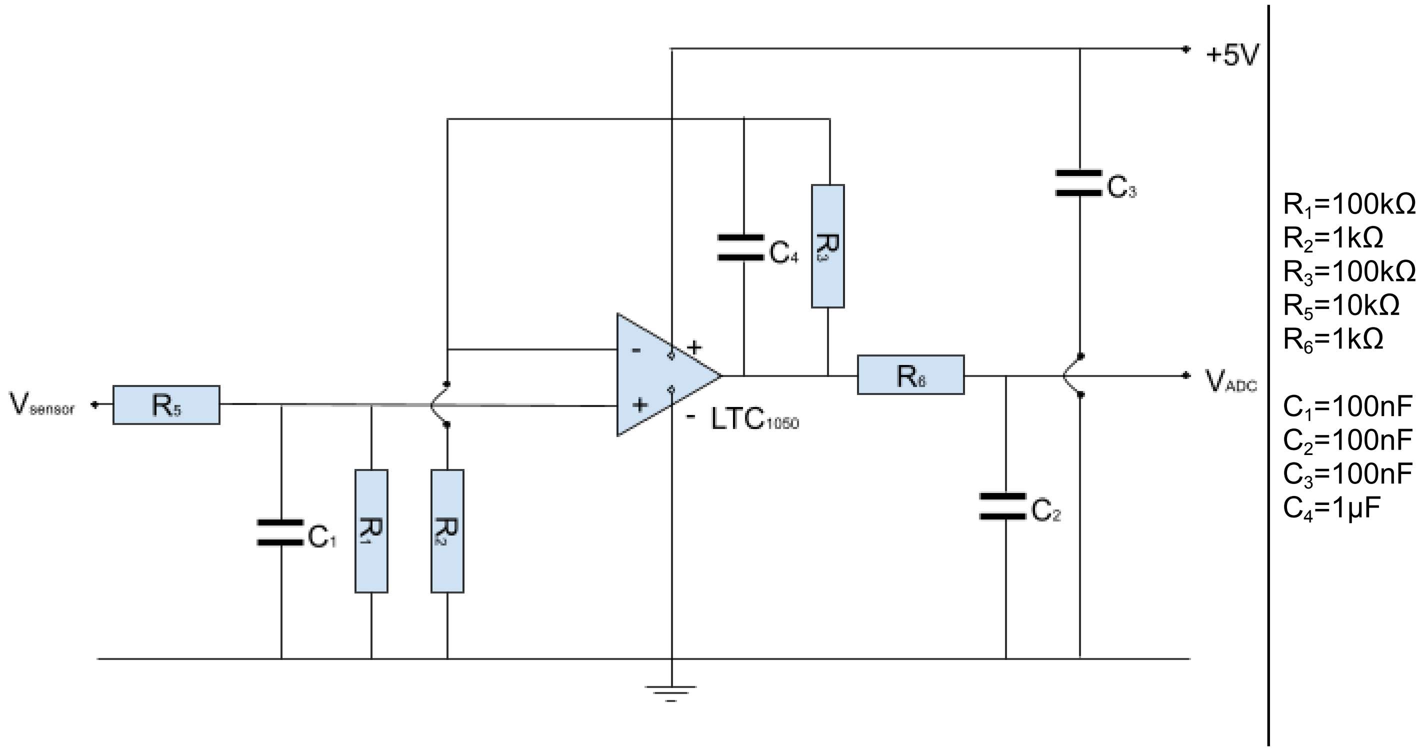


Figure 4: Electrical scheme of the sensor connections.

Above is typical application of the sensor in an analogue circuit. The sensor is connected in series with two resistors of a dividing bridge. The outcoming tension is amplified by a LTC1050 operational amplifier before being filtered by a RC filter (low pass).The tension from the ADC_sensor label can be connected to a 5V ADC (an Arduino[3]'s for instance).

[3] Arduino's input impedance is smaller than the output impedance of the sensor : $\underline{Z}_{sensor} >> \underline{Z}_{Arduino}$