INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

LSG180

Lutelle's sensors

LOW-TECH GRAPHITE STRAIN GAUGE

Features

- Low-tech / low-cost
- Easy to use and to build
- Works for both compression and tension
- Small size and ultra-light
- Easy to repair and/or replace

Figure 1 : LSG180 strain gauge

Description

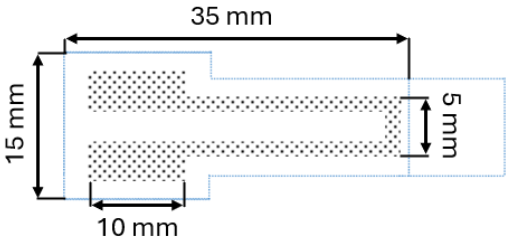
The LSG180 sensor (for Low-tech Strain Gauge) is a paper-based sensor. Indeed, it returns a different resistance depending on whether it is deformed in tension or compression. The particularity of the LSG180 is that you will build it by yourself. All you need is a printer, some thick paper and a pencil. With those items, you will just color the sensor you just printed and plug it onto your system.

Our sensor is working thanks to the graphite nanoparticles deposited on paper. When a compression is performed on the sensor, the graphite grains become closer and the resistance of the LSG180 decreases. The inverse phenomena occurs when a tension is performed on the sensor. The distance between each graphite grain increases and the resistance of the LSG180 increases as well.

As the graphite deposited on the paper is very thin, the quality of the sensor will drop if the user or anything touches it. Finally, the resistance of the LSG180 can be large and exceed the MΩ. A voltage divider may be inefficient in this case. To replace it, the schematic of a transimpedance amplifier can be found on page 7 in the datasheet.

Mechanical specifications	Electrical specifications
Height : < 0.2 mm	**Flat resistance :** 65KΩ to 11.9MΩ (depending on the pencil used)
Working angle : -65° to +75°	**Bend resistance in tension :** 73KΩ to 15MΩ at 75° (depending on the pencil used)
Temperature range : +20°C to +25°C	**Bend resistance in compression :** 131KΩ to 6MΩ at 60° (depending on the pencil used)
Pencil grades : 6B to H (according to your needs)	**Voltage supply :** 5V

Dimensions



Thickness : 0.15 – 0.2 mm

Figure 2 : Dimensions of the LSG180

Electrical characteristics depending on the pencil grades

Pencil grades	Units	Value		
		Flat resistance	Bend resistance in tension (at 75°)	Bend resistance in compression (at 60°)
6B	KΩ	64.85	72.5	131,68
5B	KΩ	93.43	104.79	-
4B	KΩ	676.02	801.86	-
3B	KΩ	650	772.29	410.48
B	KΩ	811.46	995.22	-
F	MΩ	1.09	1.58	-
H	MΩ	6.17	8.24	-
HB/2	MΩ	11.86	14.84	6,09

Typical performance curves

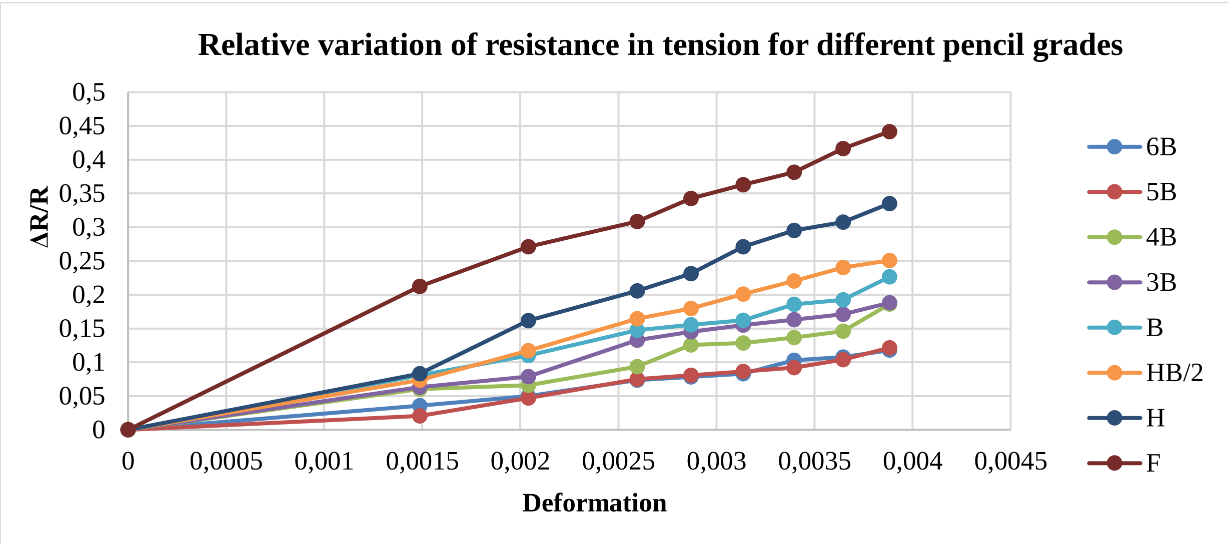


Figure 3 : Relative variation of resistance for different pencil grades

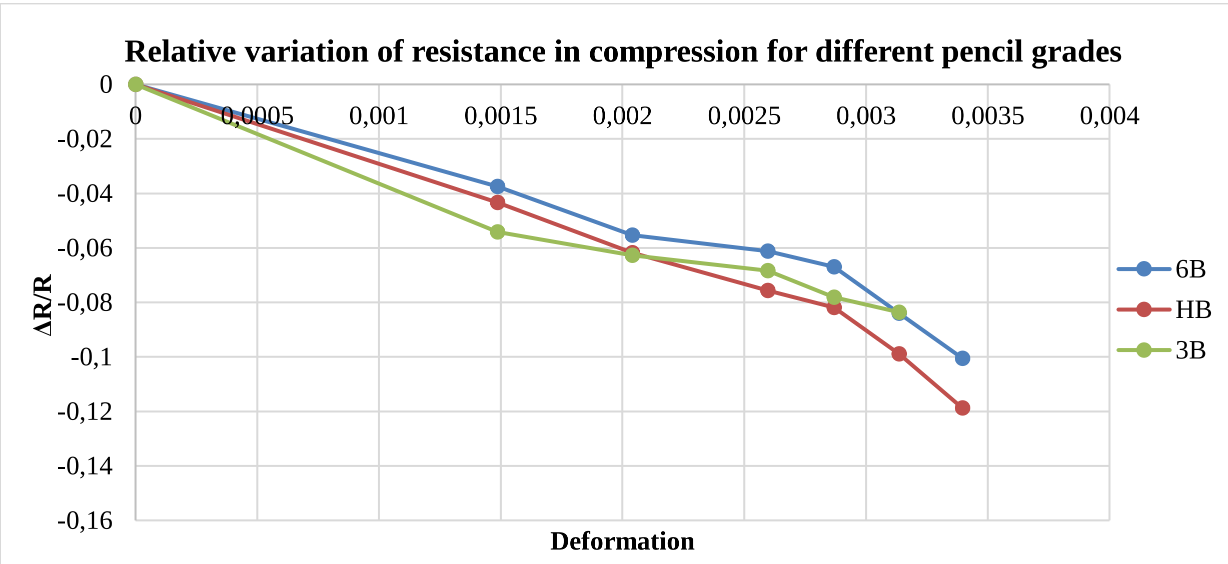


Figure 4 : Relative variation of resistance in compression for different pencil grades

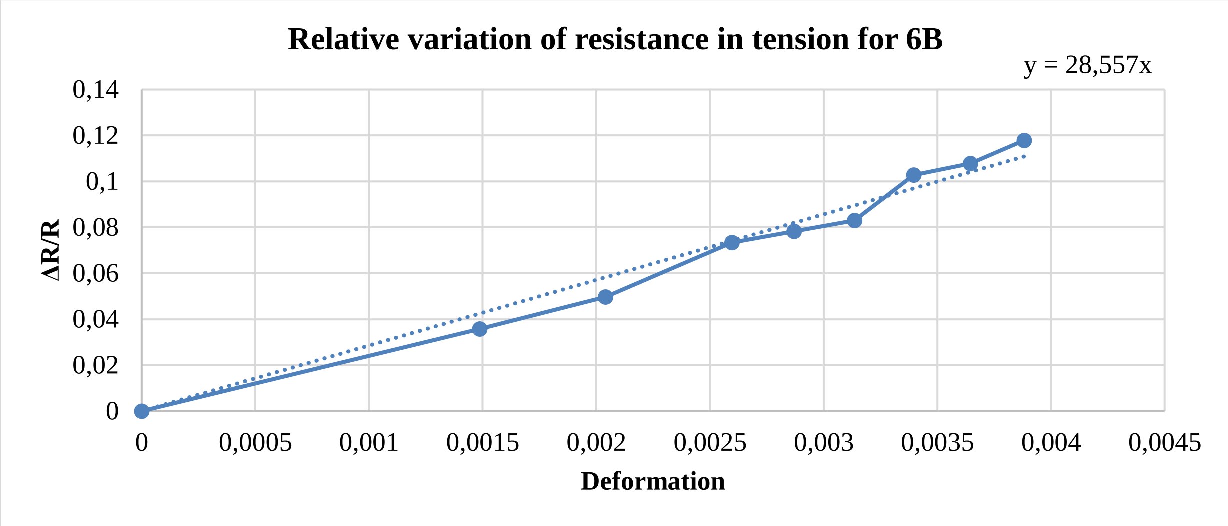


Figure 5 : Relative variation of resistance in tension for 6B

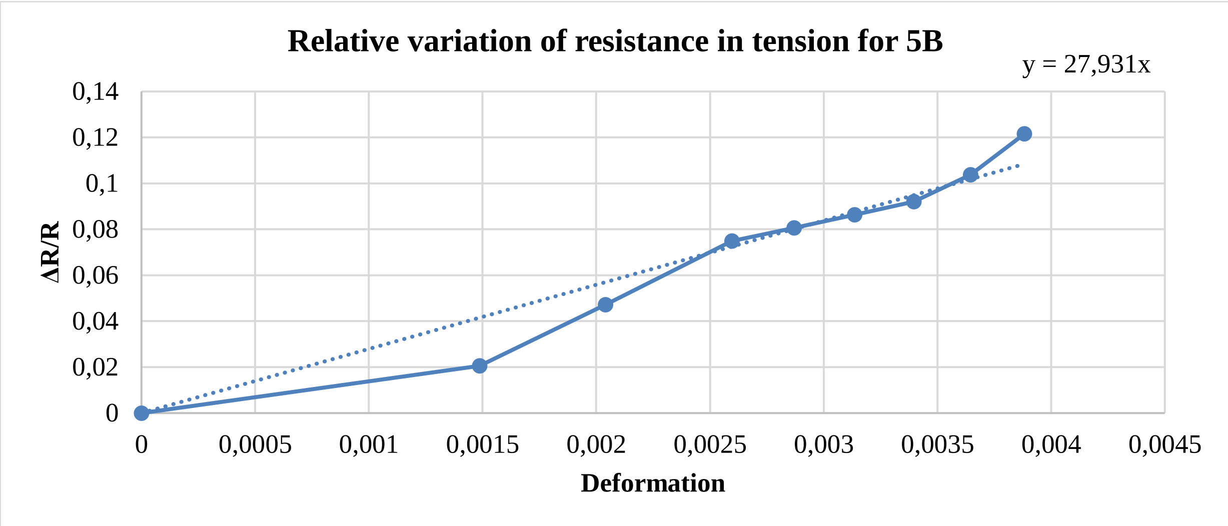


Figure 6 : Relative variation of resistance in tension for 5B

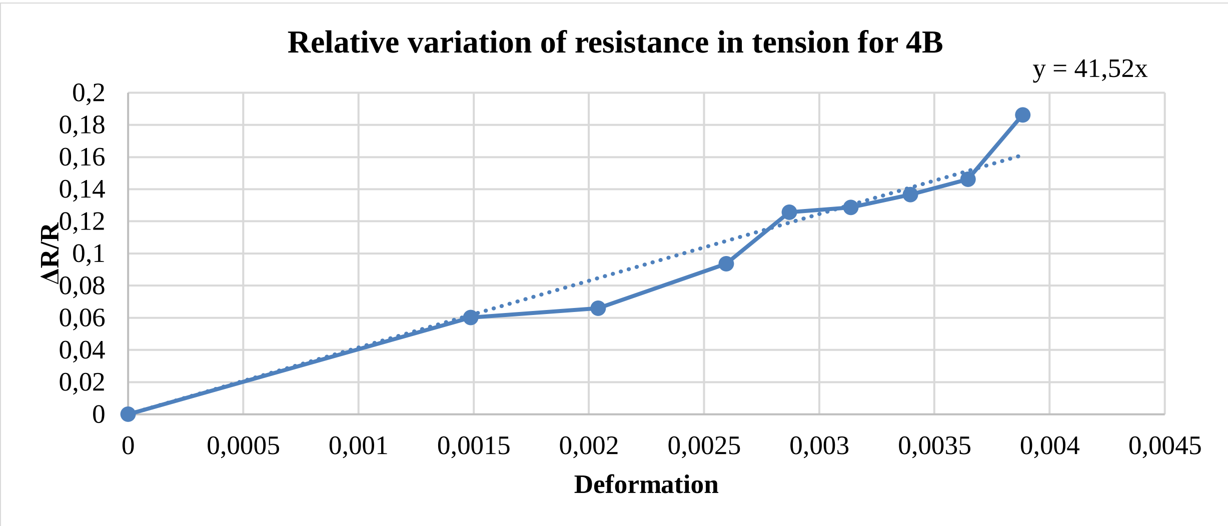


Figure 7 : Relative variation of resistance in tension for 4B

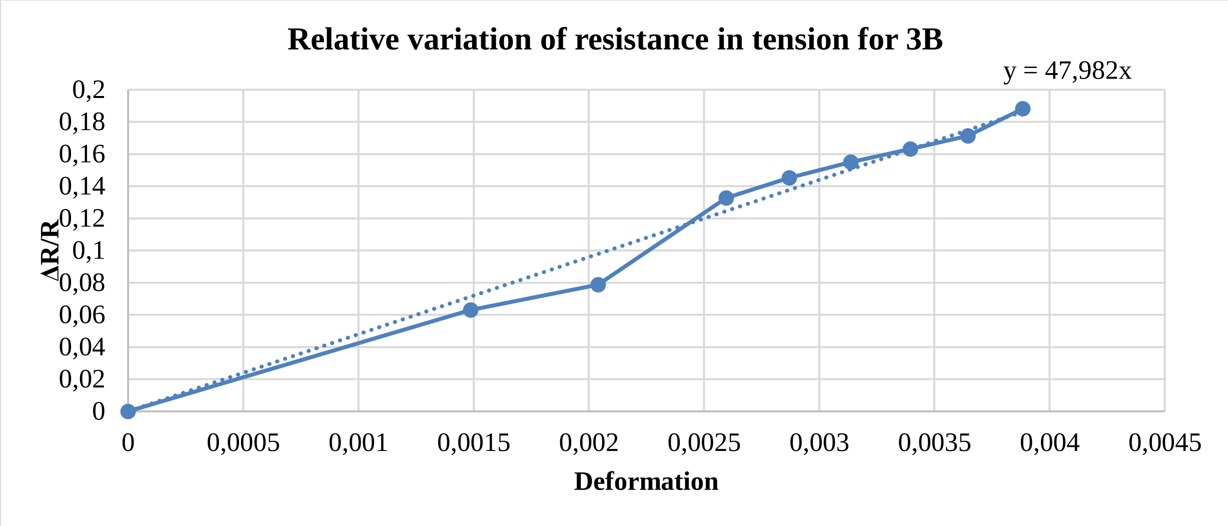


Figure 8 : Relative variation of resistance in tension for 3B

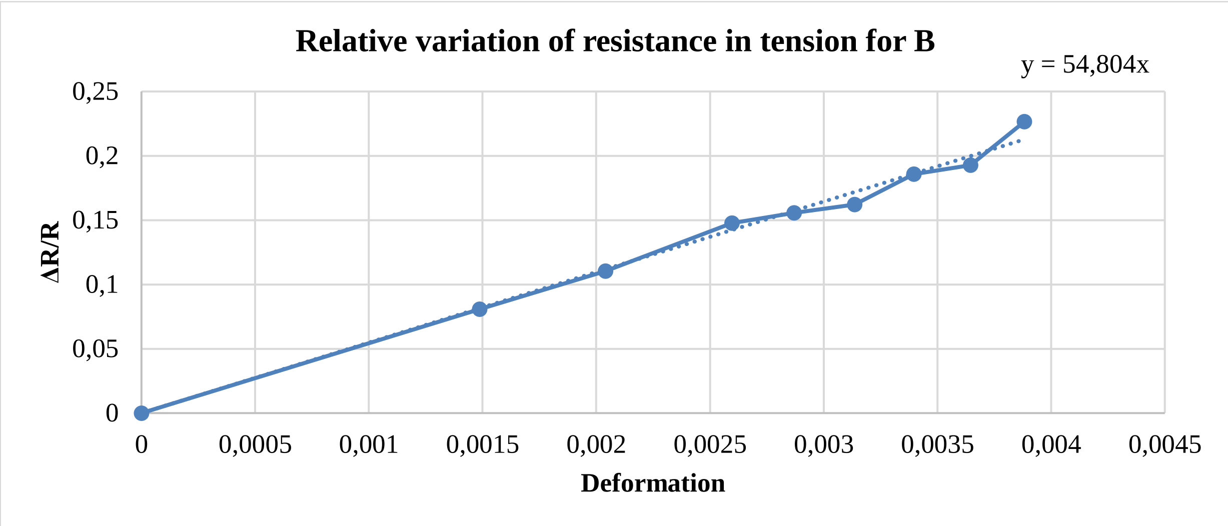


Figure 9 : Relative variation of resistance in tension for B

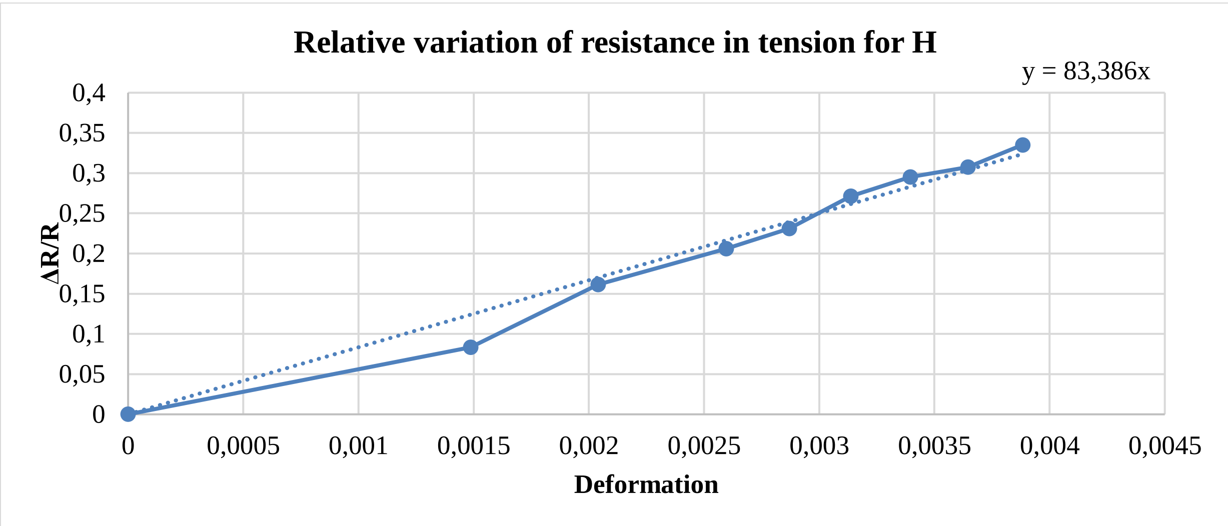


Figure 10 : Relative variation of resistance in tension for H

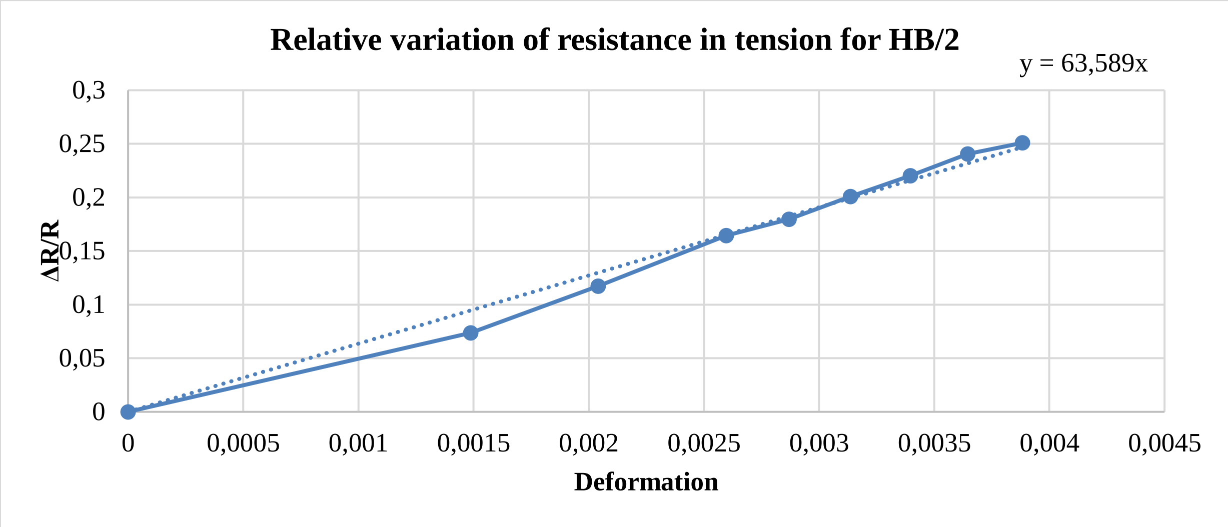


Figure 11 : Relative variation of resistance in tension for HB/2

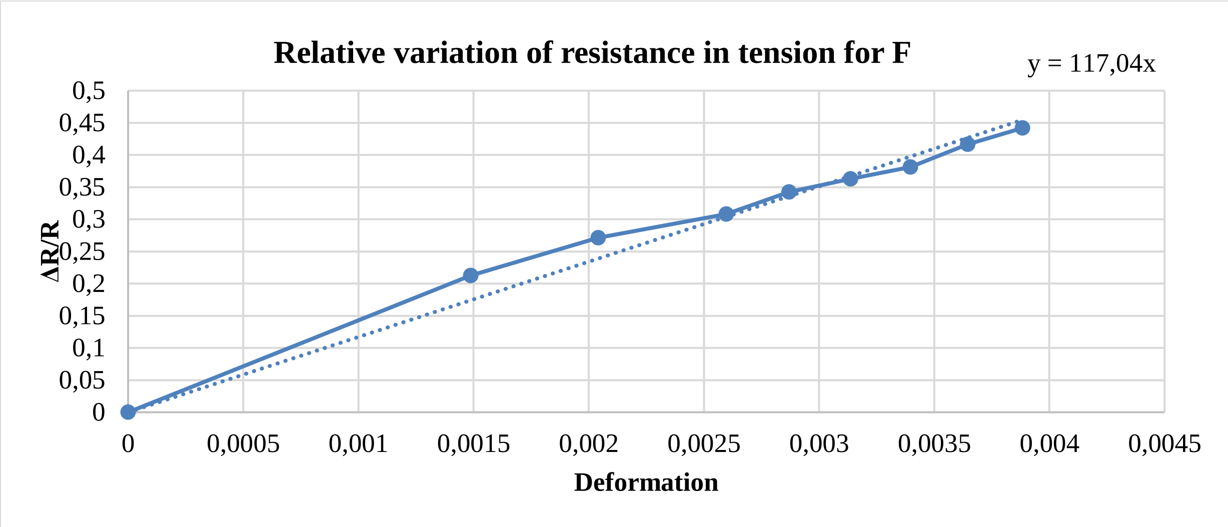


Figure 12 : Relative variation of resistance in tension for F

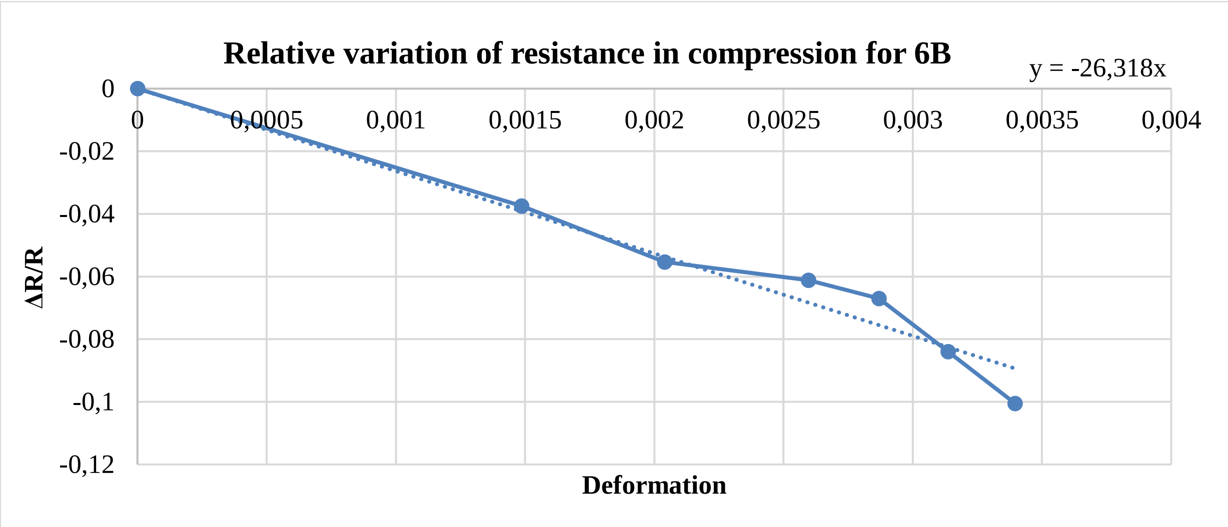


Figure 13 : Relative variation of resistance in compression for 6B

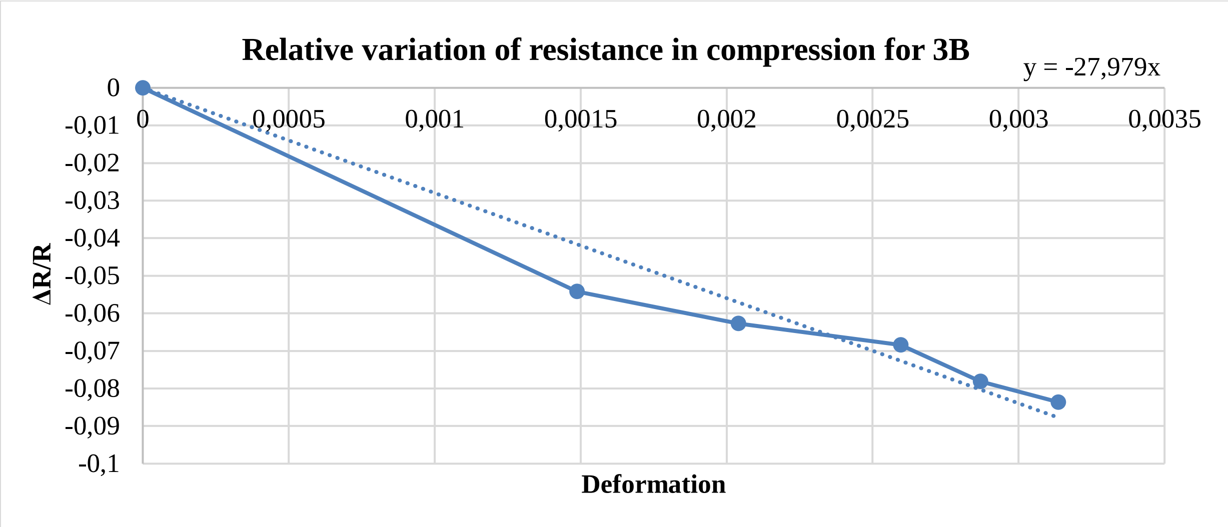


Figure 14 : Relative variation of resistance in compression for 3B

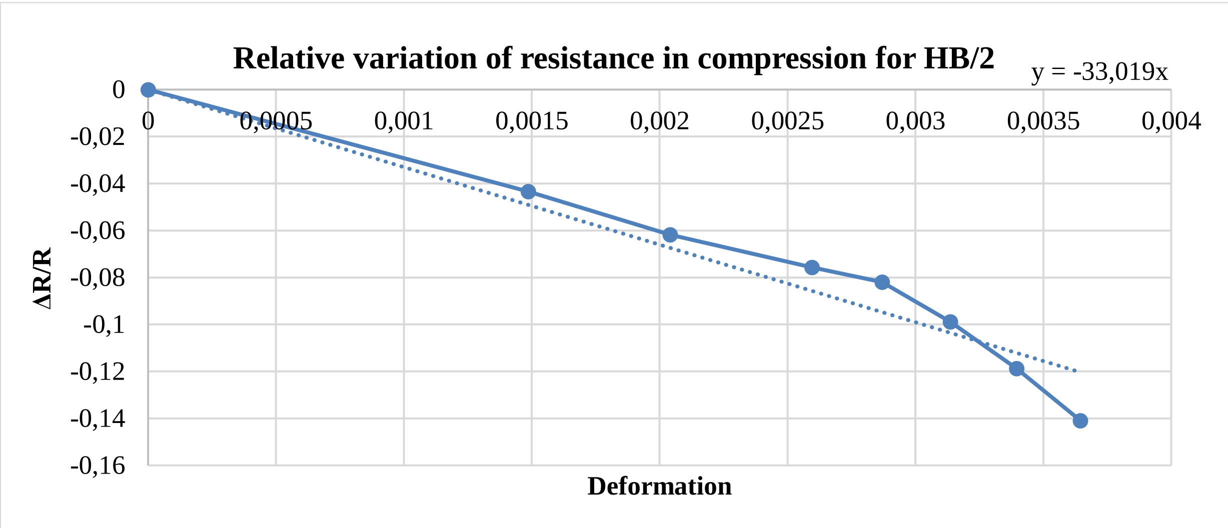


Figure 15 : Relative variation of resistance in compression for HB/2

On these graphs, the relative variation of resistance depending on the deformation is plotted. From the measurements, those values are calculated with the following equations :

$\frac{\Delta R}{R} = \frac{R_{bend} - R_{flat}}{R_{flat}}$ and $\varepsilon = \frac{e}{2 * R_{curvature}}$ with e the paper thickness and $R_{curvature}$ the radius of the arc of circle made by the paper when deformed.

From those calculations, the point (0,0) on the graphs is relevant as a relative variation of resistance is plotted. Indeed, no deformation means no variation of resistance so $\frac{\Delta R}{R} = 0$. Thus, the equation of the linear regression has a linear behavior such as $y = ax$. The coefficient a of this equation corresponds to the sensitivity of the sensor.

The sensitivities for each pencil grade are summarized in the table below.

	Sensibility in tension	Sensibility in compression
6B	28,557	-26,318
5B	27,931	-
4B	41,52	-
3B	47,982	-27,979
B	54,804	-
HB	63,589	-33,019
F	117,04	-
H	83,386	-

Figure 16 : Table of the sensibilities

Suggested applications

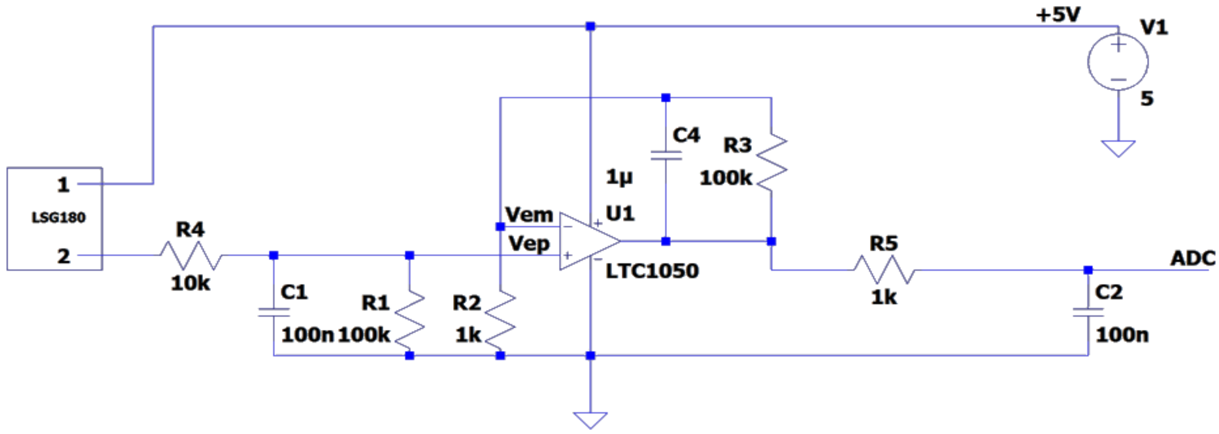


Figure 17 : Transimpedance amplifier circuit to measure the resistance value of the LSG180

To use the LSG180, an efficient way is to use a transimpedance amplifier. It allows to measure large resistances. With the circuit above, one can retrieve the resistance of the LSG180 sensor by using the following formula:

(1) $R_{LSG180} = \left(1 + \frac{R_3}{R_2}\right) * \frac{Vcc*R_1}{V_{ADC}} - R_1 - R_4$ with $Vcc = 5V$

To read the output of the transimpedance amplifier, an Arduino can be used. All you need is to plug the ADC output of the transimpedance amplifier to an analog input of the Arduino. The Arduino is reading the ADC value from 0 to 1023. To retrieve the resistance value of your sensor, you first need to convert the ADC value in volts with the following equation :

(2) $V_{ADC} = ADC * \frac{Vcc}{1023}$

Then, you can apply the formula (1) to convert V_{ADC} to the LSG180 resistance value.

For some pencil grades, you will have to read low resistance values. In this case, it is better to use a voltage divider. The corresponding circuit is presented below :

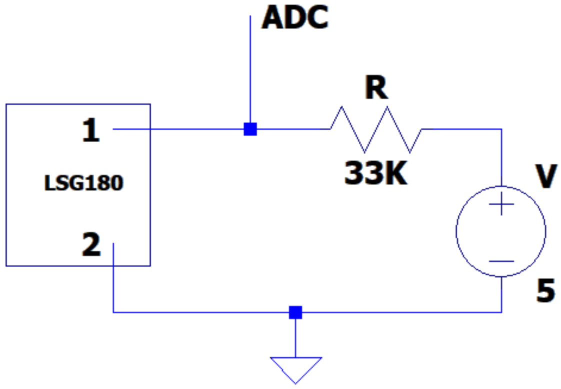


Figure 18 : Voltage divider circuit

To retrieve the resistance of the LSG180 sensor, you will need to apply the following equation : $R_{LSG180} = \frac{R * V_{ADC}}{Vcc * V_{ADC}}$