Datasheet of Pencil drawn Strain gauges on paper

Designer

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Main features

• Low cost

• Strain sensor

• Low power consumption

• Open source

• Low tech

• Intuitive app

Description of the system

This strain sensor is based on graphite resistance variation measurement. When a pencil mark is drawn on the paper, the graphite particles break off and stick to the paper (fig1.). These particles create a thin conductive film where an electric current flows.

Indeed, between each particle of the graphite film, there is a tunneling current that is proportional to the distance between the particles. Therefore, any expansion or contraction of the paper will affect the contact between the particles and thus induce an electric current

When a compressive stress is applied to the sensor so that the carbons are closer together, current flows more easily: resistance decreases. On the other hand, when a voltage strain is applied to the sensor, the measured resistance will increase. We used different pencils (B, HB, HB2) and measured the variation of the resistors for each according to the radius of curvature. A PCB shield including the sensor has been created and fabricated. It is combined with an analog circuit, designed to interface with strain sensors.

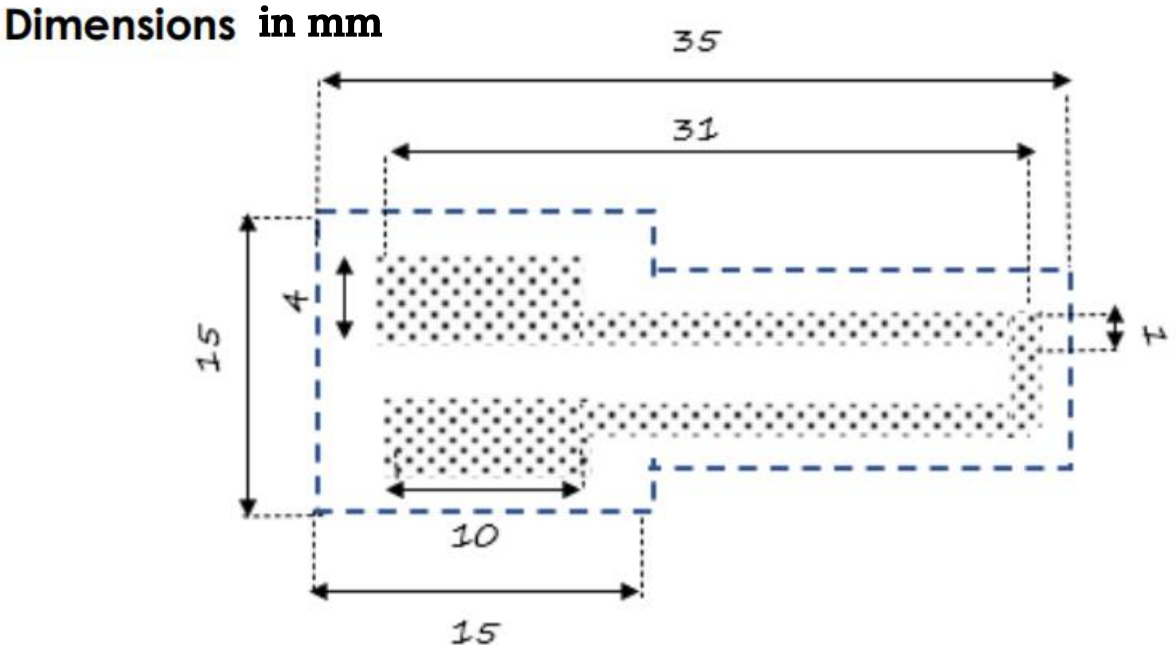
Resistor value is displayed on live Oled display. Oled can also display tension we measure but click of switch button of rotary encoder.

The Android app (made with app inventor) plots the variation of the resistor value over time and display the value of tension we measure. You must pair the HC05 Bluetooth module with your smartphone. After your smartphone knows the HC05, you can launch the acquisition of values.

Specifications

Type	Strain sensor
Materials	-Graphite pencil (HB, HB/2, B) -Paper -Cooper clips
Power supply	5V
Dimension	-Arduino uno size:1.8*4.8*6.4cm (portable) -Sensor size (Fig 1)
Nature of output signal	Analog
Measurands nature	Deformation of strain sensor (here deflection)
Temperature of work	10 -30°C
Application	Resistance and voltage monitoring (With compression or tension deformation of the sensor)

Fig 1



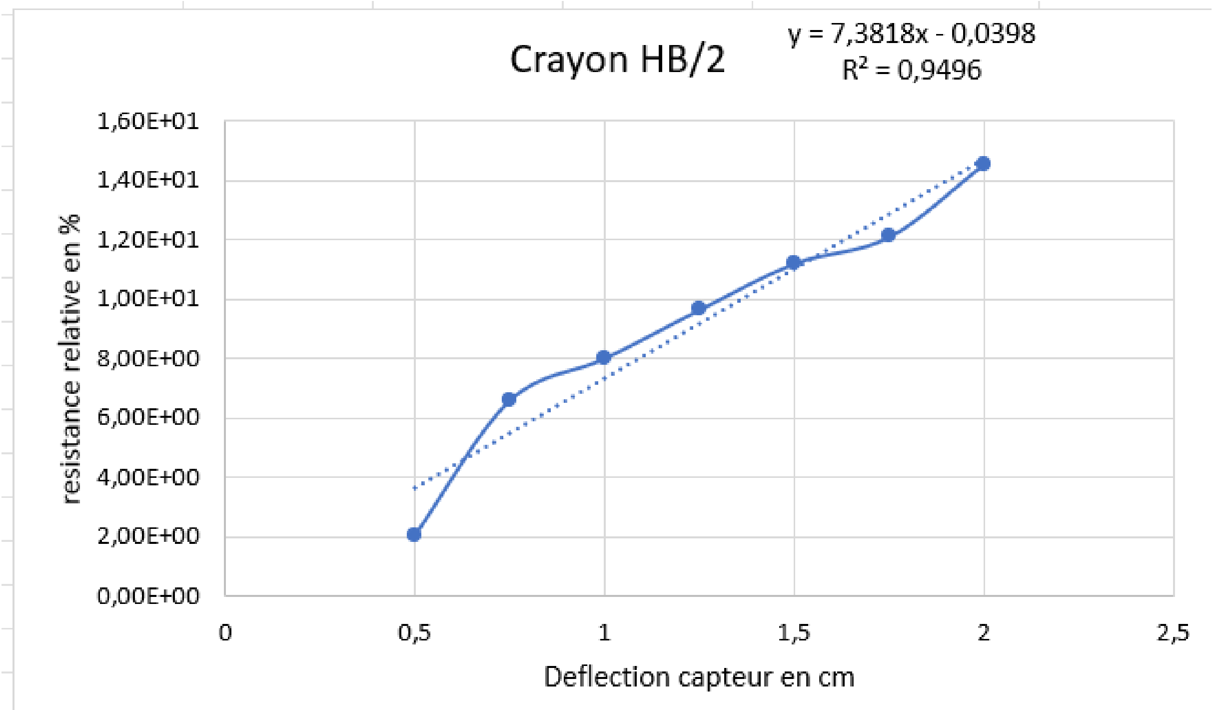
Strain sensor Characteristics

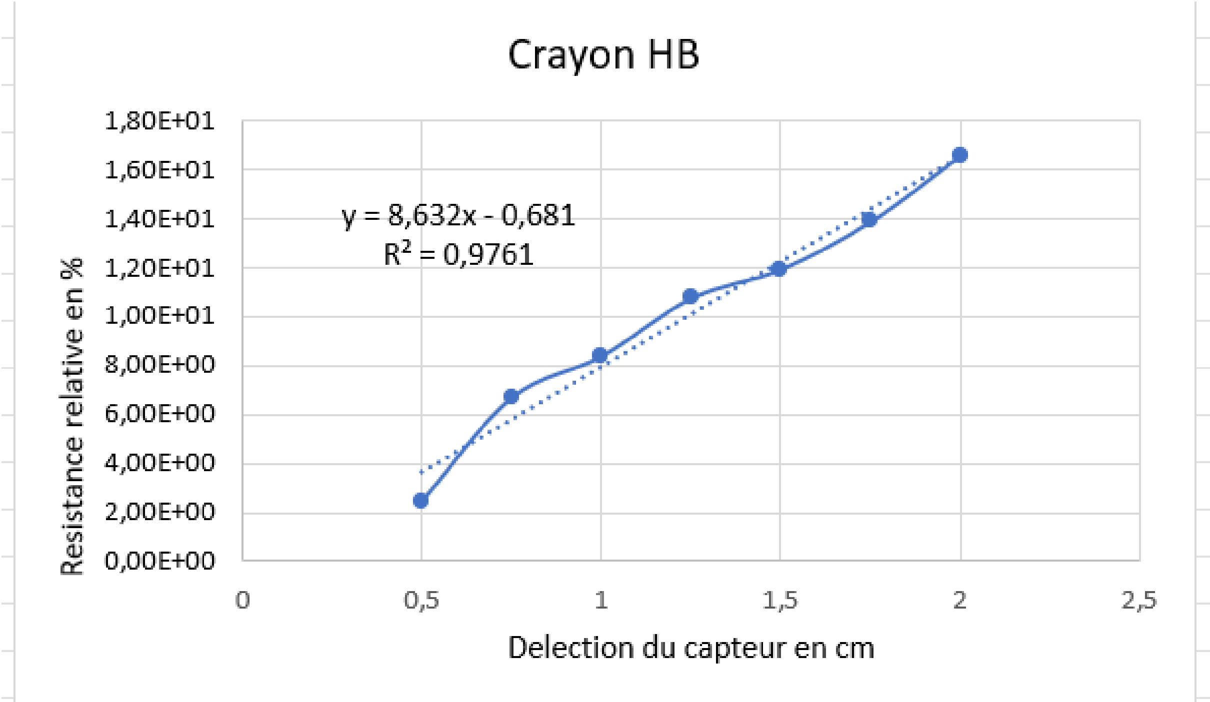
The value of the sensor resistance depends on several parameters. It depends largely on the amount of graphite applied to the paper, as well as the size of the pencil and the fineness of its grain. It is important to note that the more graphite is used, the greater the differences in resistance.

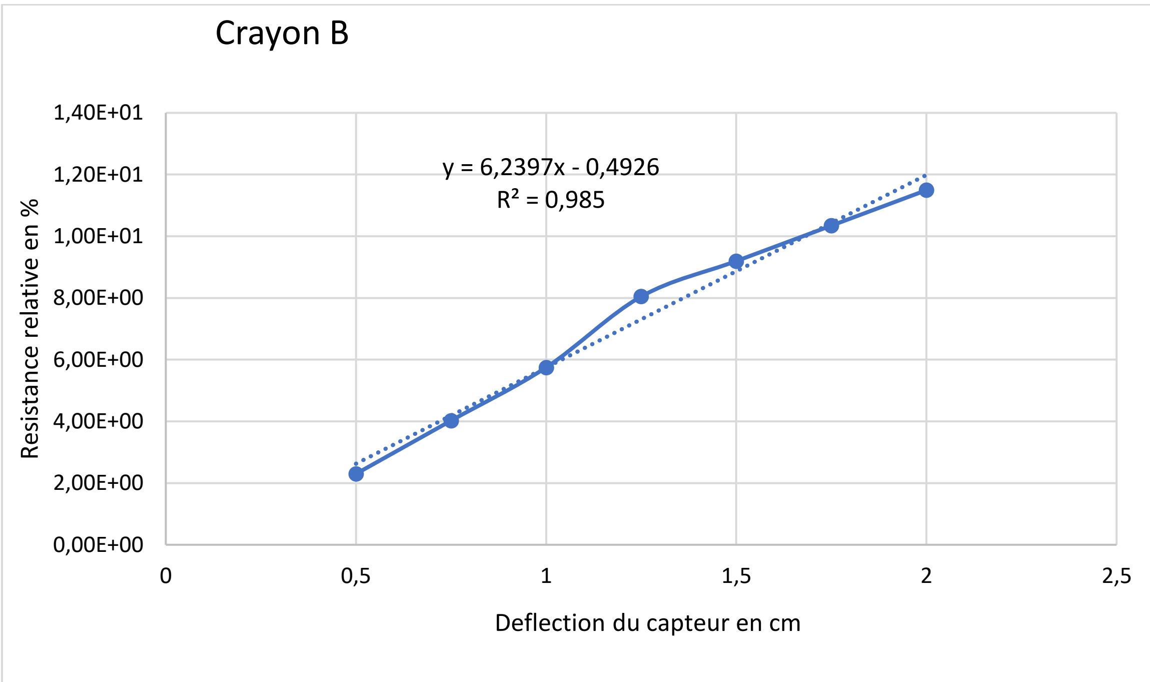
It should be noted that beyond 10 measurements the deformation of the sensor becomes irreversible (the sensor has difficulty returning to its initial shape). It is therefore necessary to change the sensor to obtain reliable results.

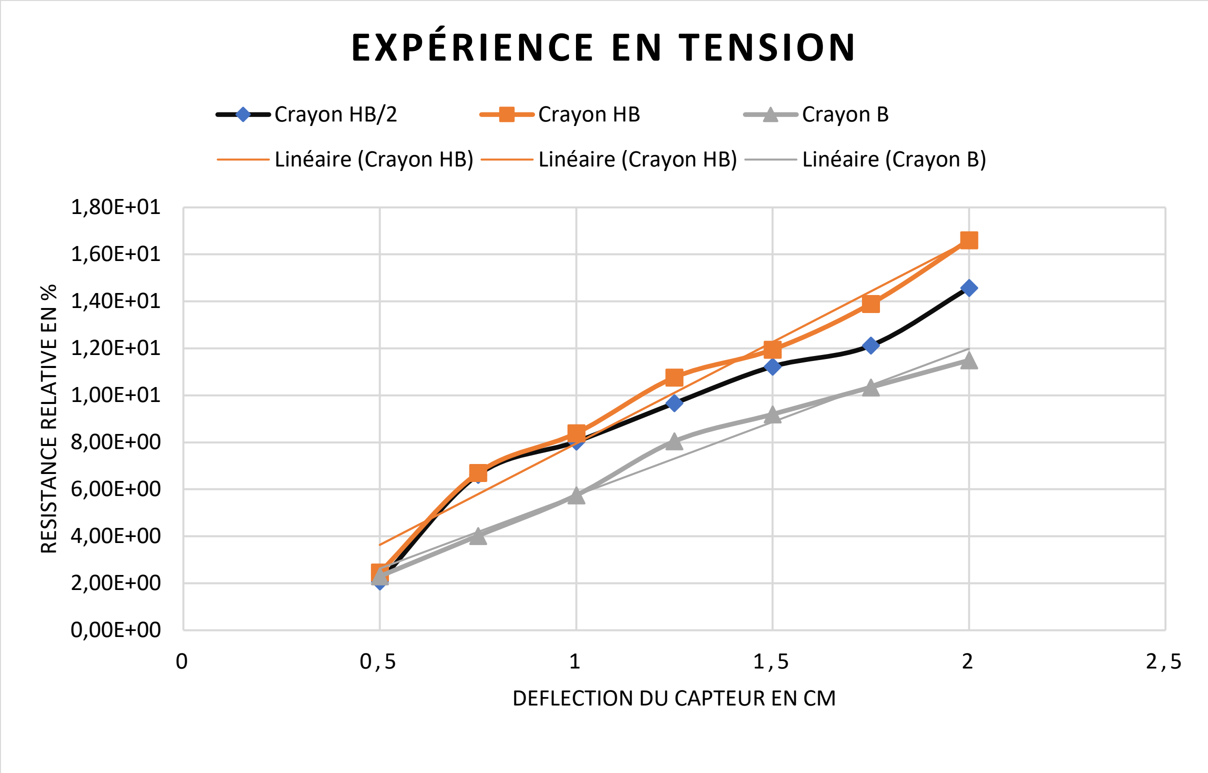
We have chosen to plot the relative variations of the resistance (rate of variation of the resistance compared to R0 measured when the sensor is not deformed) $\frac{\Delta R}{R_0}$.

Here are the resistance variation curves for HB/2, HB, and B pencils.




Crayon HB
y = 8,632x - 0,681
R² = 0,9761
Resistance relative en %
1,80E+01
1,60E+01
1,40E+01
1,20E+01
1,00E+01
8,00E+00
6,00E+00
4,00E+00
2,00E+00
0,00E+00
0
0,5
1
1,5
2
2,5
Delection du capteur en cm


Crayon B
y = 6,2397x - 0,4926
R² = 0,985
Resistance relative en %
1,40E+01
1,20E+01
1,00E+01
8,00E+00
6,00E+00
4,00E+00
2,00E+00
0,00E+00
0
0,5
1
1,5
2
2,5
Deflection du capteur en cm



Conclusion

The resistance without applying of deflection R0 for HB, HB/2 and B is 135MΩ, 118MΩ and 87MΩ respectively. The softer pencil B has the lower resistance.

Under tensile deformation, graphite particles were moved away which gives higher resistance. Then, for tensile deformation traces drawn with HB and HB/2 give the greatest response because they are harder pencils.

We have linear fits for the change in resistance with the equation y=9.632x (R^2=0.9761) for HB device, y=7.3818x ($R^2 = 0.9466$) for HB/2 device, y=6.2397 ($R^2 = 0.985$) for B device.

We can give the sensibility of each sensor by taking the slope and its unit will be in Ω/cm. As HB has the greater resistance it is very sensitive than the to other.