The-Bao PHAM
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2024_4GP_INSA Toulouse

Technical Datasheet: Graphite Strain Sensor

General features

- Open Source
- Low Cost
- Easy to Use
- Thin and light
- Simple Fabrication
- Bluetooth Connection
- Low Power Consumption

Description:

The graphite strain sensor is an ingenious device designed to measure mechanical deformations in compression and tension. It's simple and affordable design uses basic materials such as paper and graphite pencil (HB, 2B, 3B, 5B).

By drawing a 'U' shaped structure on a piece of paper, the sensor is created with graphite deposits acting as the strain gauge. When the sensor is deformed, whether in compression or tension, it detects variations in electrical resistance. In compression, the graphite particles come closer together, forming new conduction paths and reducing resistance. In tension, the particles move apart, breaking some conduction paths and increasing resistance. Its low cost, ease of fabrication, and responsiveness make it an attractive choice for those seeking an effective strain measurement solution.

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Schema and Pin Description:

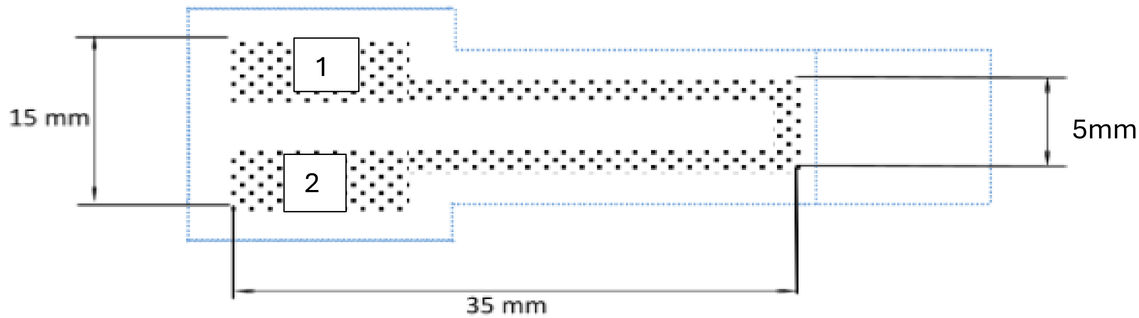

Figure 1: Sensor schematic

Pin number	Usage
1	+VCC (5V)
2	Analog Output

Specifications:

Type	Graphite based sensor
Sensor type	Passif
Materials	• Paper • Pencil lead (C, O, Mg, AL, Si) • Metal clips (to connect to circuit)
Mesurande	Resistance
Power supply	5V
Application typique	Mesure the deformation mechanism under compression and tension
Temps de réponse typique	< 1s
Mounting	Through hole fixed

Standard use conditions :

	Unit	Typical value
Temperature	°C	20±5
Humidity	%	60±10

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Electrical characteristics:

The resistance value of this sensor depends on the thickness of graphite layer and the type of pencil we used to create the sensor. The softer the pencil lead, the smaller the resistance since it contains more graphite particles than the hard pencil leads.

Type of pencil lead	**Unit**	**Value**		
		Min	Typical	Max
HB	MΩ	8,5	12	14,5
2B	MΩ	3,5	5	6,5
3B	MΩ	2,2	4,5	5,3
5B	kΩ	440	530	660

Sensibility:

Type of pencil lead	**Unit**	**Value**
HB	MΩ	35,56
2B	MΩ	33,987
3B	MΩ	23,85
5B	kΩ	29,53

<u>TEST BENCH:</u>

To study the characteristics of the sensor we use the following tesh bench:

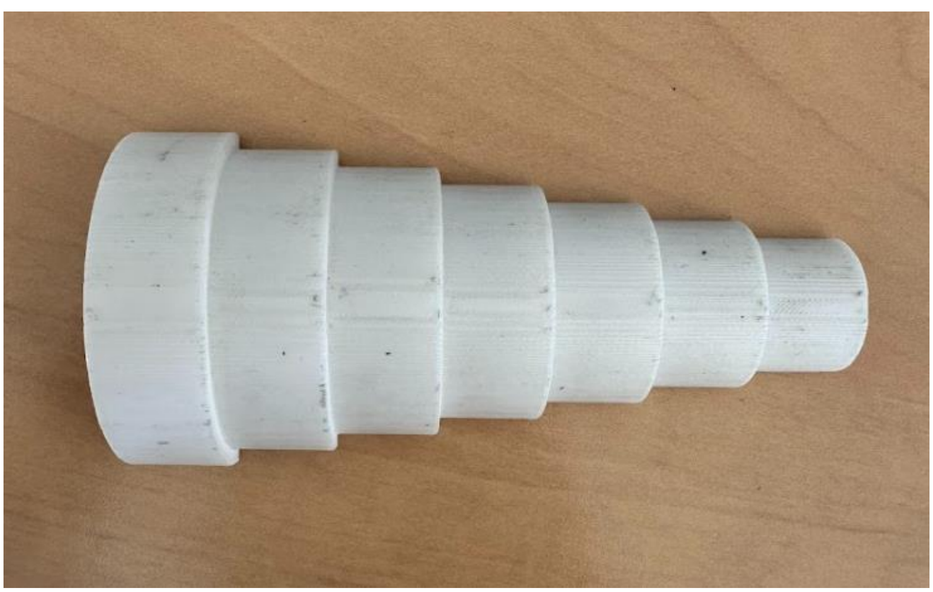

Figure 2: 7 3D printed semi-cylinder used for the test bench

It consists of 7 semi-cylinders arranged sequentially from small to large. The diameter of each semi-cylinder ranges from 2cm to 5cm with a step of 0,5cm. We will study the resistance of the sensor according to its deformation by bend it over the cylinders. The deformation is calculated by the following formula:

$$\varepsilon = \frac{e}{2r}$$

Where: ε is the deformation

e is the thickness of the paper sheet

r is the radius of each semi-cylinder

For the thickness e, we took the value 0,16mm which is the grammage of sheet 140g/m^2. We measured the deformation of our sensors under both compression and tension.

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SENSOR CHARACTERISTICS:

1. The deformation under tension:

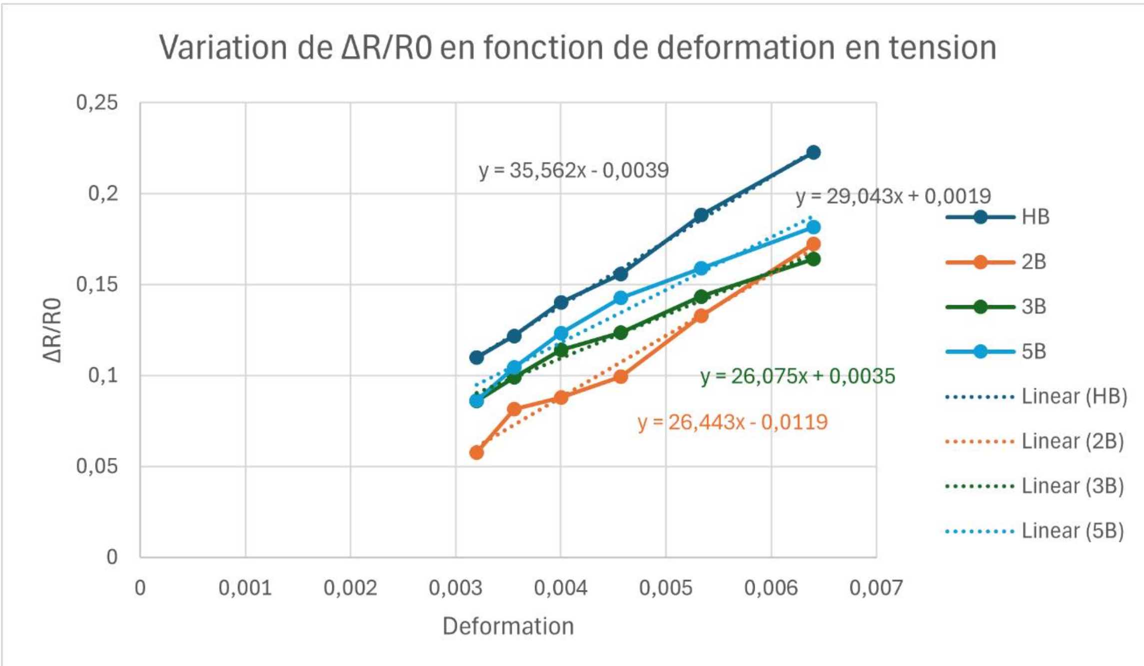

Figure 3: Formation of the sensor under tension

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2. The deformation under compression:

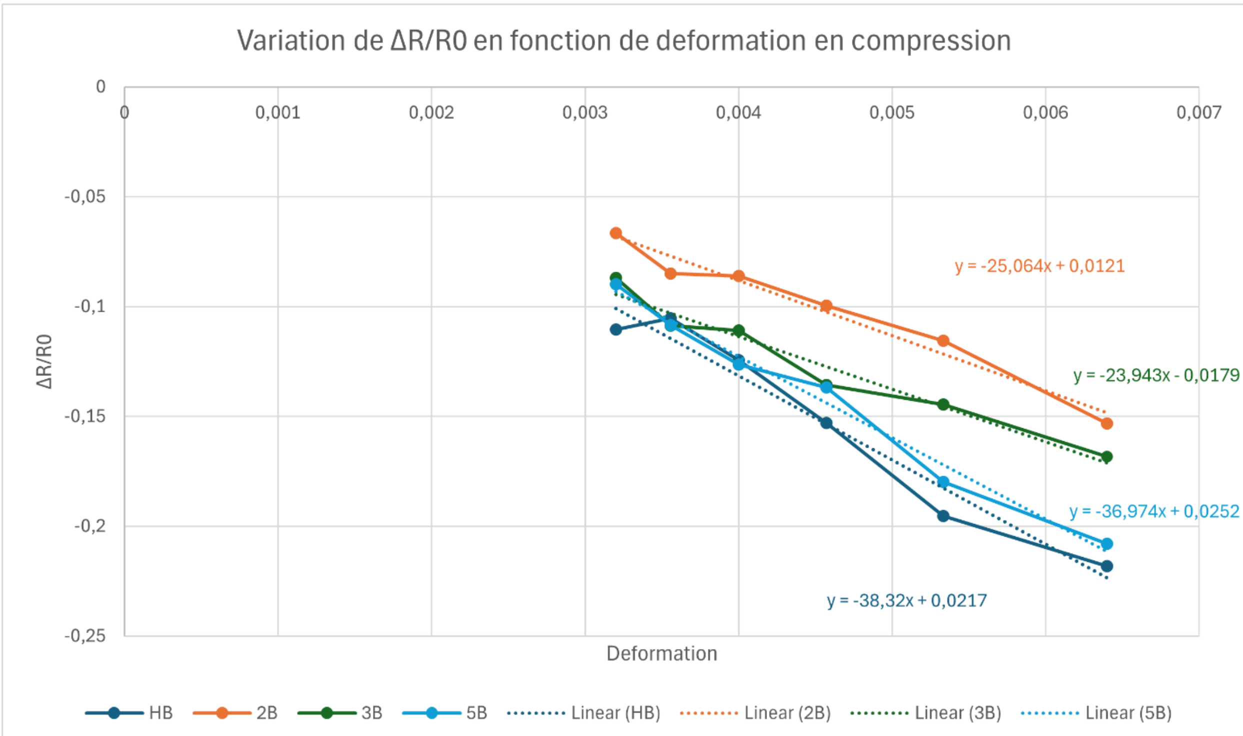

Figure 4: Formation of the sensor under compression

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Typical Applications:

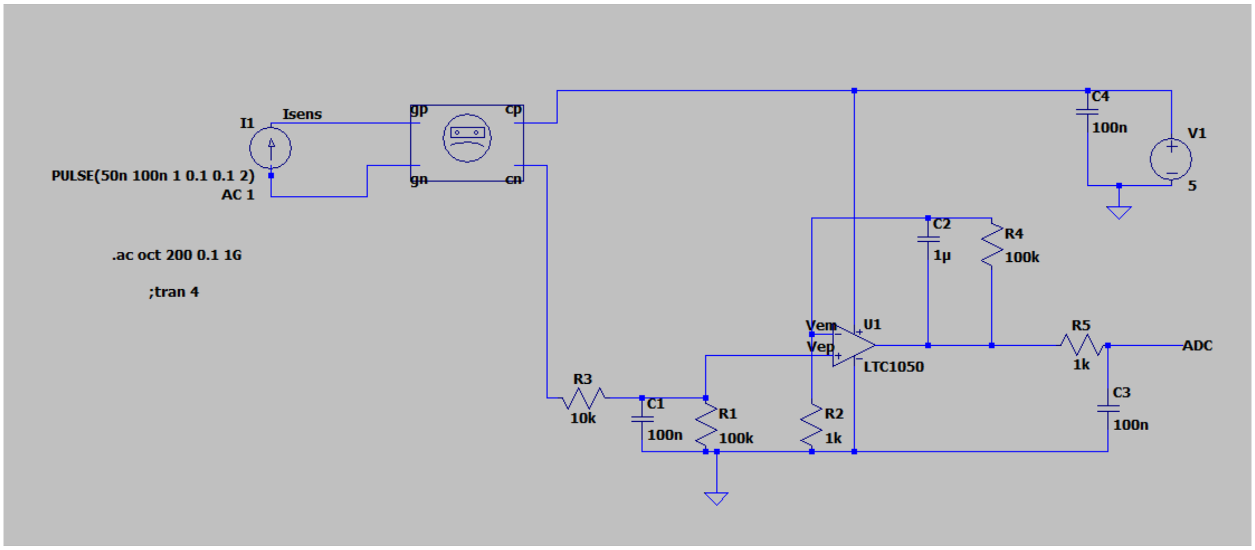

Figure 5:Schematic of a typical graphite sensor application.

The graphite strain sensor is integrated into an analog circuit with an LTC1050 operational amplifier to provide an adequate voltage signal to the ADC of an Arduino UNO microcontroller. This circuit has three filter stages to optimize the signal:

- A low-pass filter at the input (R1, C1) with a cutoff frequency of 16 Hz to remove the current noise in the input signal.
- Another low-pass filter (R4, C2) with a cutoff frequency 1.6 Hz to eliminate the 50 Hz noise from the power grid.
- The output filter (R5, C3) with a cutoff frequency 1.6 kHz to filter the ADC noise.

The resistance R3 at the input serves to safeguard the operational amplifier against electrostatic discharges and forms an RC filter with C1 to mitigate voltage noise. The resistance R2 is changeable for calibration adaptation. The capacitor C4 is used to filter the power supply noise. This configuration ensures a precise output signal from the graphite strain sensor, eliminating unwanted interference.

The formula used to calculate the resistance of the graphite strain sensor is as follows:

$$R_{sensor} = \left(1 + \frac{R4}{R2}\right) * R1 * \frac{VCC}{VADC} - R1 - R3$$