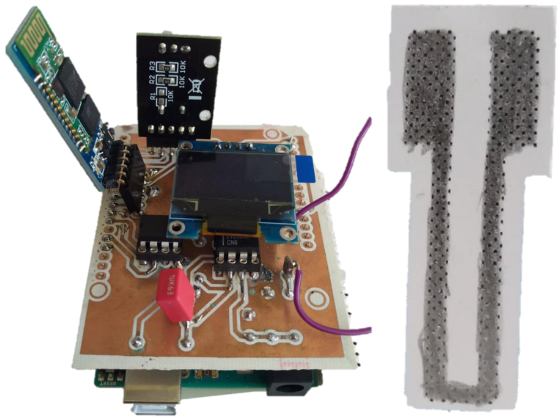
Graphite Strain Sensor GSS-GPINSA-39708



1 Main features

- Low-tech
- Low power consumption (5V)
- Low cost
- Small size and light weight

2 General description

Low-tech graphite strain sensor (passive sensor) conditioned by an analog electronic circuit that communicates data via a microcontroller to an Android application developed as part of INSA Toulouse Applied Physics curriculum. The sensing element is a piece of paper with graphite deposited with pencil in a "U" shape. The amount of graphite impacts the resistance variation. It is possible to add/remove graphite from the sensor whenever the user wants with variable pencils (9B to 9H pencils). The sensor is coupled to an analog circuit, to amplify and filter the low signal from sensor. This strain sensor uses percolation theory in granular system. When compressed, molecules bond together. When stretched, molecules move away and the resistance increases. Strain sensor measures a resistance.

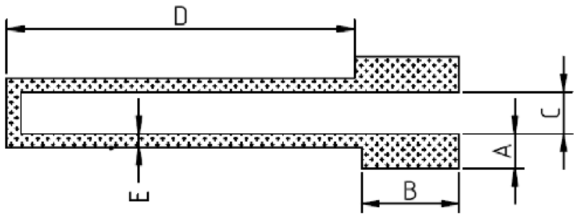
3 Standard use conditions

	Unit	Value
Temperature range	$^{\circ}C$	-20 to 70
Humidity	$\%$	60±5
Pressure	bar	1

Warning: it is advised to protect the flex sensor shield when unused to minimize corrosion of the copper.

4 Technical specifications

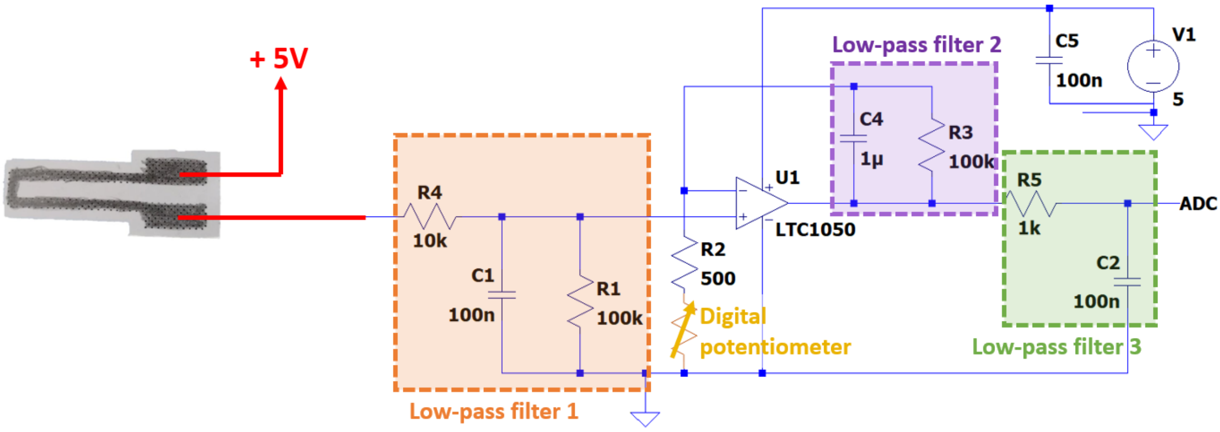
	Unit	Value
Power voltage	V	5
Sensor dimensions	$mm * mm * mm$	35*25*1 (without clamps)
Complete package dimensions	$mm * mm * mm$	54*74*73 (without cables)
Sensor weight	g	5 (without cables)
Complete package weight	g	37
Number of inputs	$--$	2
Voltage range signal output	V	0 to 5
Response time	ms	700 to 1000
Materials	$--$	Graphite sheet (carbon), paper



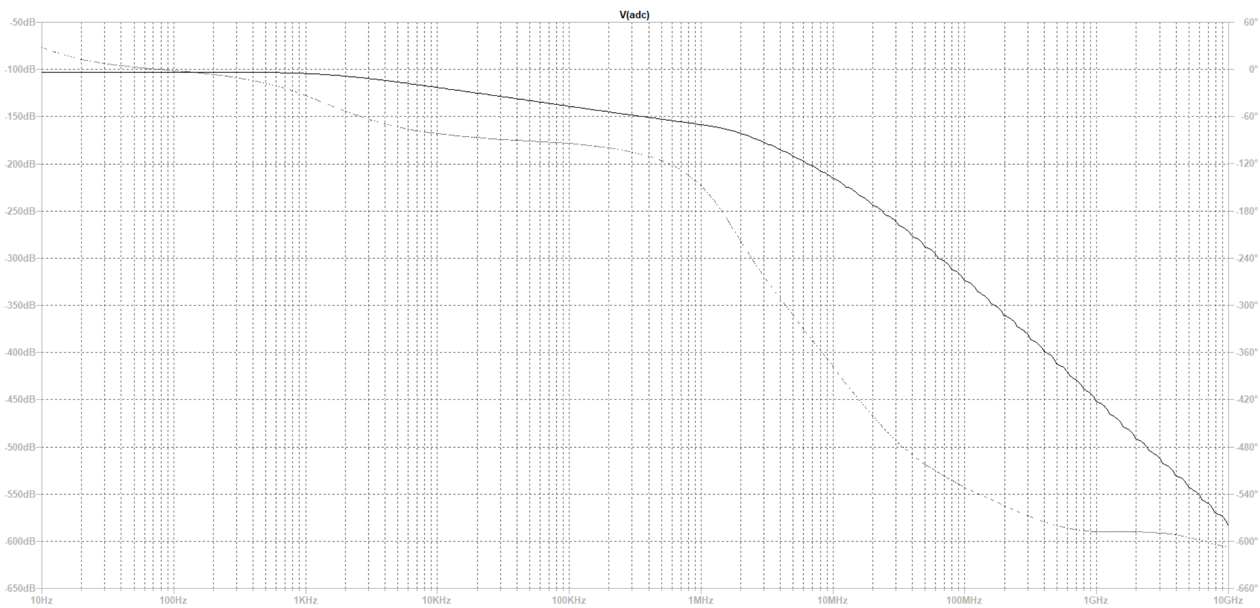
		Unit	Value
A	Connexion pad width	mm	4
B	Connexion pad height	mm	10
C	Gap between pads	mm	3
D	Sensor length	mm	23
E	Sensor thickness	mm	1.5

Both pads of the sensor are connected to the circuit with crocodile clips.

5 Signal conditioner



Component	Unit	Value	Quantity
Resistance	$k\Omega$	100	2
Resistance	Ω	500	1
Resistance	$k\Omega$	10	1
Resistance	$k\Omega$	1	2
Capacity	μF	1	1
Capacity	nF	100	3
Operational amplifier	$--$	LTC1050	1
Digital potentiometer	$--$	MCP41050	1



	Unit	Value
Cutoff frequency low-pass filter 1	Hz	16
Cutoff frequency low-pass filter 2	Hz	2.1
Cutoff frequency low-pass filter 3	kHz	1.6
Gain	$--$	3.13 to 127.9
Noise attenuation at 50 Hz	dB	100

6 Additional modules

Additional modules are contained in the complete package:

- **Bluetooth HC05** : the Android application communicates over bluetooth with the HC-05 module, and allows to measure and plot resistance and voltage over time. Main features:
  - Display measured voltage and resistance numerically and ploted as a function of time;
  - Update gain if modified on the shield;
  - Save measured data points in a text file.
- **OLED screen I2C 0.91** : the OLED screen shows a drop menu. The user can chose to print the voltage, resistance and to calibrate the measure.
- **Rotary encoder KY_040** : to chose the different option in the drop menu.
- **Digital potentiometer MCP41X1** : to change the resistance in series with R2 to adapt to the measure. Pin 8 (P0A) is connected to R2 wich is 500 Ω.

7 Connections

Component	Pins on Arduino Uno	Component pin
Bluetooth HC05	5V	2 (VCC)
	GND	3 (GND)
	6	4 (TxD)
	7	5 (RxD)
OLED I2C 0.91	GND	1 (GND)
	5V	2 (VCC)
	A5	3 (SCK)
	A4	4 (SDA)
Rotary encoder KY_040	3	1 (CLK)
	4	2 (DATA)
	2	3 (SWITCH)
	GND	5 (GND)
	5V	4 (VCC)
Digital potentiometer MCP41X1	10	1 (CS)
	13	2 (SCK)
	11	3 (SDI/SDO)
	GND	4 (VSS)
	5V	5 (VDD)
	GND	6 (P0B)
	GND	7 (P0W)
	-	8 (P0A)
Strain sensor and conditionner	5V	1 (5V)
	A0	2 (ADC)

8 Characteristics and response

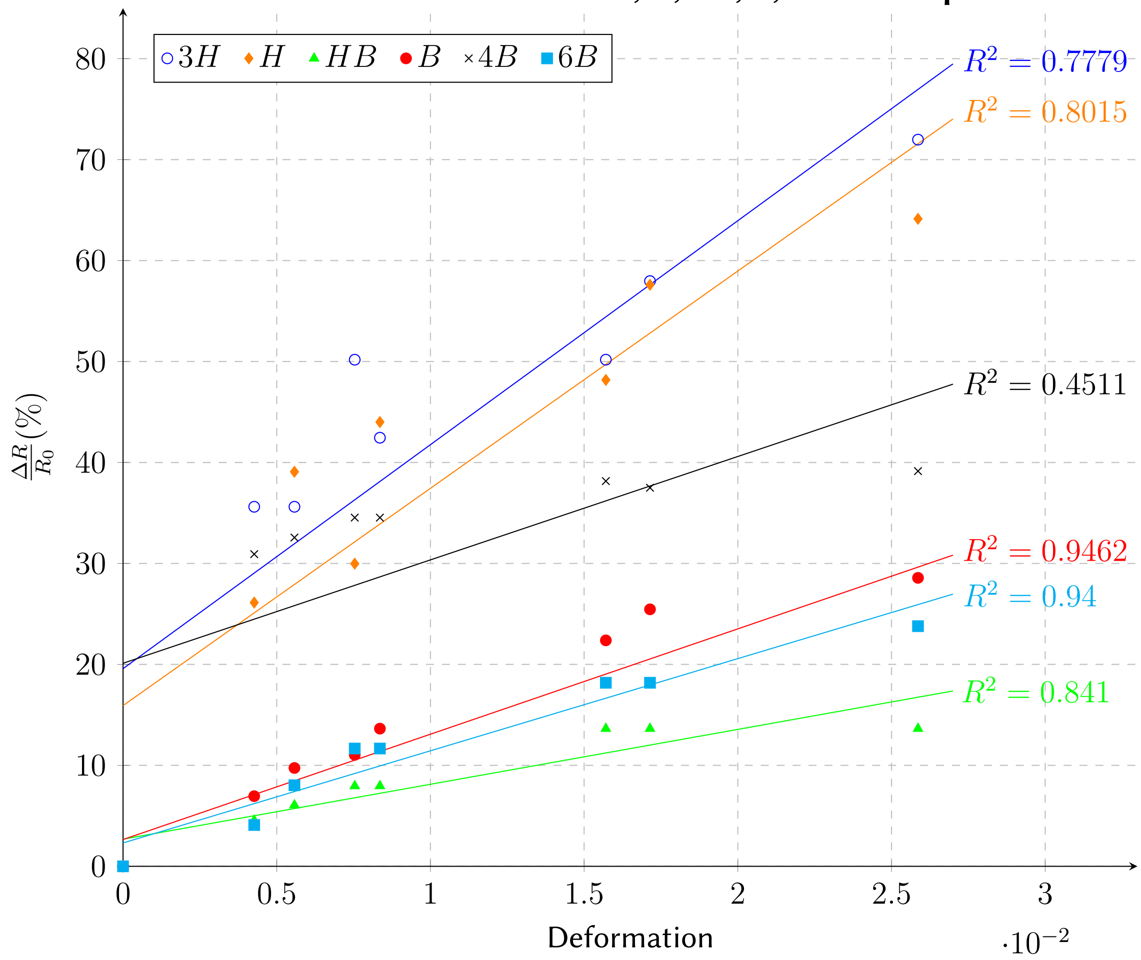
Device	Measured R range (MΩ) (*)	Gain (to start at 1V)
3H	150 to 1100	127.9
H	150 to 1100	127.9
HB (**)	1.1 to 2.2	3.74
B	5.4 to 13	18.62
4B	0.9 to 2.7	3.13
6B	0.4 to 3.2	3.13

(*) Low resolution with high gain and 10 to 8 bit mapping

(**) 10 % denser lead mine with a ceramic cell structure, higher graphite density than other HB pencils

Diameter in cm for cylindrical test objects	Deformation
7,03	0.004
5.38	0.006
3.98	0.008
3.59	0.008
1.91	0.016
1.75	0.017
1.16	0.026

Comparison of change in normalized resistance versus deformation under compressive deflection for devices drawn with 3H, H, HB, B, 4B and 6B pencils



Comparison of change in normalized resistance vs. deformation under tensile deflection for devices drawn with 3H, H, HB, B, 4B and 6B pencils