Graphite sensor
INSA Toulouse

Low-cost Graphite strain sensor coupled to an analogic electronic circuit

General features

- Low Power consumption
- Open source
- Low cost
- Voltage and resistance analyse
- Bluetooth connexion available
- OLED screen display
- Low precision for HB/2H

Description

This strain sensor is based on a graphite's resistance and voltage detector. When a pencil trace is drawn on a paper, graphite particles rub off and stick to the paper. Those particles will create a thin conductive film where the current will flow. Indeed, between each particles of the graphite films, exist a tunnelling current proportional of the distance between the particles. Therefore, any expansion or contraction of the paper will affect the inter particles contact and so the resulting current. The resistance we measure thanks to the sensor highly depends on the type of pencil we used. Indeed, each pencil does not leave the same size of particle resulting in a variation of resistance.

The resistance value is displayed on an Oled screen on live. The android app "TP5" draw the variation of the resistance value through time. It is available at the following link: http://ai2.appinventor.mit.edu/b/agl4. Before using the app, you need to pair the HC-05 Bluetooth module to your smartphone. Once the HC-05 is known by your smartphone you can then, and only then, launch the app.

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Specifications

Type	Deformation sensor
Sensing principal	Tunnelling current between graphite particles
Materials	Cooper, plastic, graphite
Power supply	5V
Overall dimensions	Arduino Uno size: 1.8x4.8x6.4cm
Measurands	Voltage
Nature of Output signal	Analog
Voltage output range	0-5 V
Resistance output range	B: 20-100 MΩ 2H: 600-2000 MΩ HB: 1000-3000 MΩ
Response time	<100ms
Working time	1 hour for 1 pencil drawn paper
Working temperature	10°C - 30°C
Typical application	Resistance and voltage monitoring due to deflection of graphite

Important information:

This is a low-cost sensor using other modules like an HC-05, Oled screen or rotatory encoder. Please make sure to respect the working principles of those modules before using our sensor. If you use our sensor in the condition mentioned above, you should NOT have any issue. However, we do not take responsibility of the deterioration of the different module you use for this sensor

Detailed sensor

As mentioned above, the sensor uses a U-shaped drawing paper to measure the voltage and resistance of the graphite. The bared area represents the graphite drawing

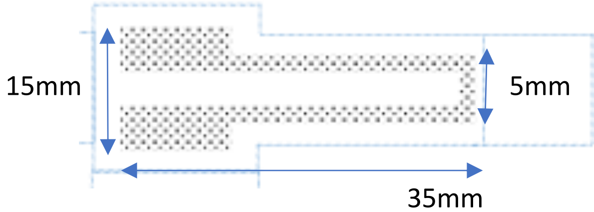

Figure 1 Strain gauge

The Resistance of the sensor is typically a dozen of Mega Ohm. In order to get a precise measure of this resistance we developed an electronic circuit able to measure resistance from 10MOhms to 500Mohms. We use an MCU (Arduino UNO) to calculate the value of the measurement, send it to an android application and displays it to an Oled screen. The sensor is connected to the MCU shield with two cooper's clips disposed on the drawing part of the paper. The shield hosts a transimpedance circuit, signal shown in figure 2 and 3, to convert the resistance values into a voltage. The two clips are represented by the Cp and Cn branches.

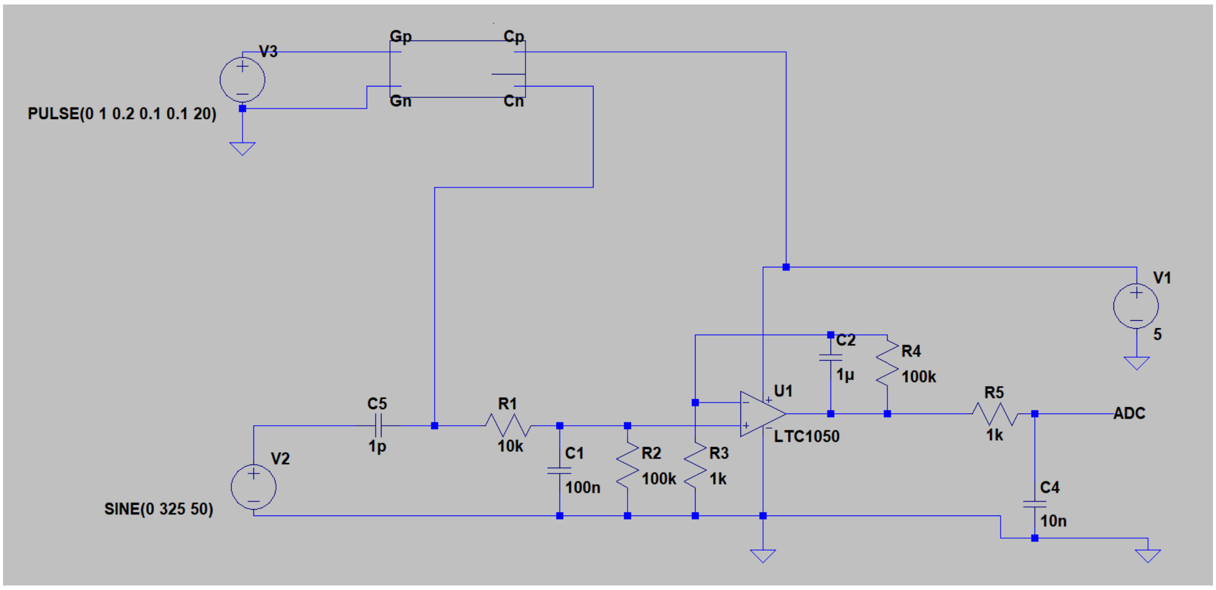

Figure 2 Transimpedance circuit

The shield also hosts the Oled screen, the Bluetooth module HC-05, the rotatory KY-040. The shield characteristic and routing are represented below in figure 3.

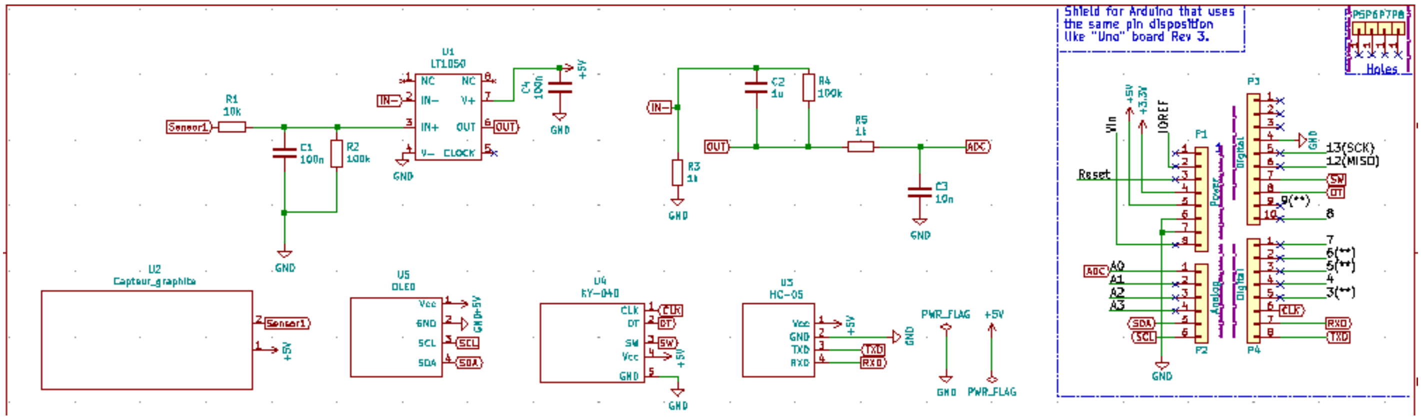

Figure 3 Overall circuit

The connexion specification of the components on the shield are listed in the table below:

Device	Arduino Uno board Pin	Device Pin
Strain sensor	A0	1
	5V	2
OLED screen	Vin	VCC
	GND	GND
	A5	SCL
	A4	SDA
HC-05 Bluetooth module	Vin	VCC
	GND	GND
	0	TX
	1	RX
KY-040	Vin	V+
	GND	GND
	11	SW
	10	DT
	2	CLK

This configuration is the one we use on our PCB and Arduino's code. You can change it, is so, you will need to change the code on the GitHub.

Calibration

The resistance value of the sensor depends on many parameters. It highly depends on the amount of graphite deposited on the paper, but also of the type of the pencil and its grain fineness. It important to notice that the more we use the sensor, the higher the variation of resistance increase. This phenomenon is explained by the deterioration of the sensor contacts as we use it. Therefore, we estimated the work time on a single sensor at 1 hour. To avoid having larges gap between measures of deflection we chose to compare the relative variation of resistance and not the absolute values. The transimpedance amplifier circuit is scaled for B and 6B type pencil. It can be upper scaled by changing the resistance R2 (see figure 2). Here is the curve of the variation of the resistance measurement for the B pencil and 6B pencil.

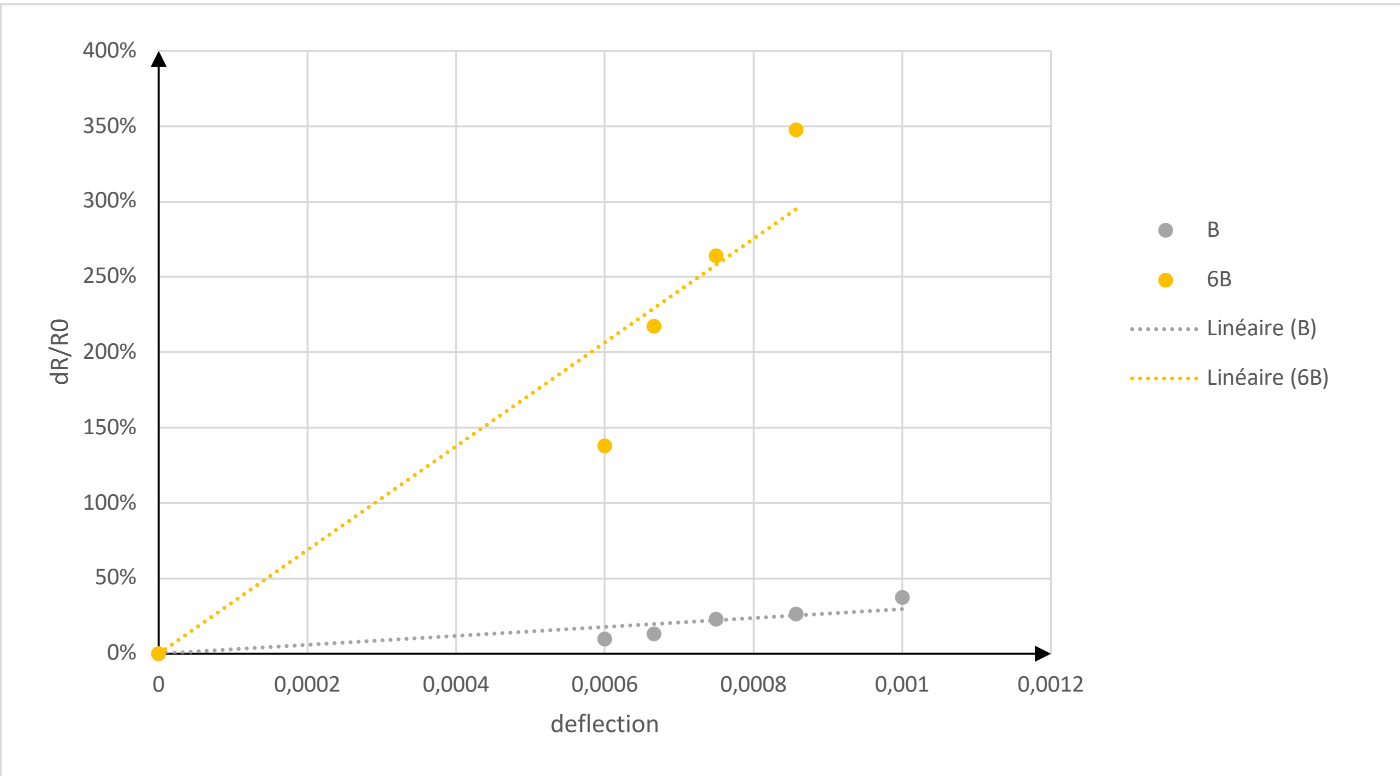

Figure 4: response of the graphite sensor for different type of pencil

The 6B sensitivity is higher but it is harder to obtain a good precision, the measure is very noisy. We recommend using the B pencil with the initial scaled transimpedance amplifier. As mentioned before, you can replace the R2 resistance by a potentiometer of 200kOhms to change the amplifier gain and use other pencil type. If you do so, don't forget to change the R2 value in the Arduino code (see figure 5 below).

```
#include <splash.h>
#include <Adafruit_GFX.h>
#include <Adafruit_GrayOLED.h>
#include <Adafruit_SPITFT.h>
#include <Adafruit_SPITFT_Macros.h>
#include <gfxfont.h>
#include <SoftwareSerial.h>
#include <SPI.h>
#include <Wire.h>


#define baudrate 9600
#define R2 100 // en kOhms

//HC-05
#define rxPin 1
#define txPin 0
```

Figure 5: First lines of the Arduino code