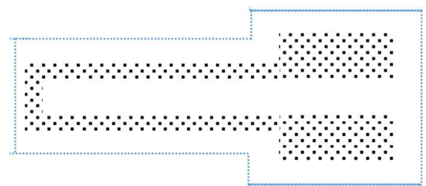
Yoann LAI KOUN SING
Ly Hai HOANG
Viet Hoang PHAM

CG-YVH25

Low tech strain gauge sensor on graphite pencil

General features

- Low power consumption
- Easy to use
- Low cost
- Small size
- Flexible
- Bluetooth connection
- Environmentally friendly

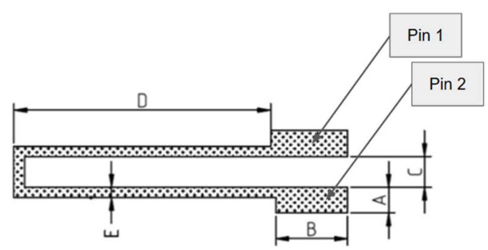


Description

The **CG-YVH25** is a flexible, low-cost strain gauge sensor made from graphite nanoparticles deposited using a standard pencil on paper. This sensor leverages the piezoresistive properties of granular graphite systems to detect mechanical deformation such as bending or stretching. Its simplicity allows for rapid prototyping and educational use, while still being capable of integration into more complex systems through Bluetooth-enabled readout.

Pin Description

Number of pins	Connection
1	Connected to the circuit power supply $+V_{CC} = 5V$
2	Connected to the conditioning circuit input



Specifications

Parameter	Value
Sensor type	Passive graphite strain gauge sensor
Measurand	Resistance
Output Signal Type	Analog
Power Supply	5V
Typical Response Time	< 100 ms
Substrate Material	Cellulosic plant fibers (paper)

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Graphite Composition	Graphite nanoparticles deposited using a graphite pencil (2H, H, HB, B, 2B)
Paper Thickness	~0.2 mm

Standard use condition

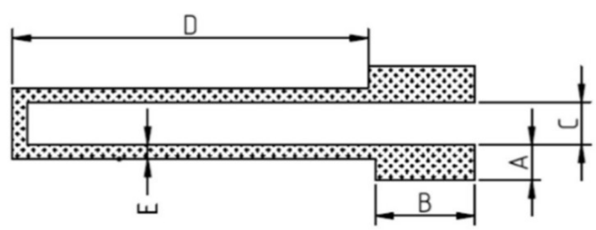
Condition	Typical value	Unit
Temperature	20±5	°C
Humidity	60±5	%
Bluetooth distance	2±2	m

Electrical characteristics

Pencil type	Unit	Measured R range	Typical R_0 rang
HB	MΩ	11.4 – 29.4	12.4 – 16.4
4B		45.0 – 55.6	50.4 – 51.1

Dimensions

Measure	Distance (mm)
A	3.5
B	10
C	3.5
D	23
E	1.5



Test bench

We use a 3D model consisting of circular slots with different radii. By inserting the sensor into the slots, deformation is created depending on the orientation of the sensor (tension or compression). The deformation is inversely proportional to the radius of the circular slots, as follows:

$$\varepsilon = \frac{\sigma}{E} = \frac{e}{R} = \frac{0.2\text{ mm}}{R}$$

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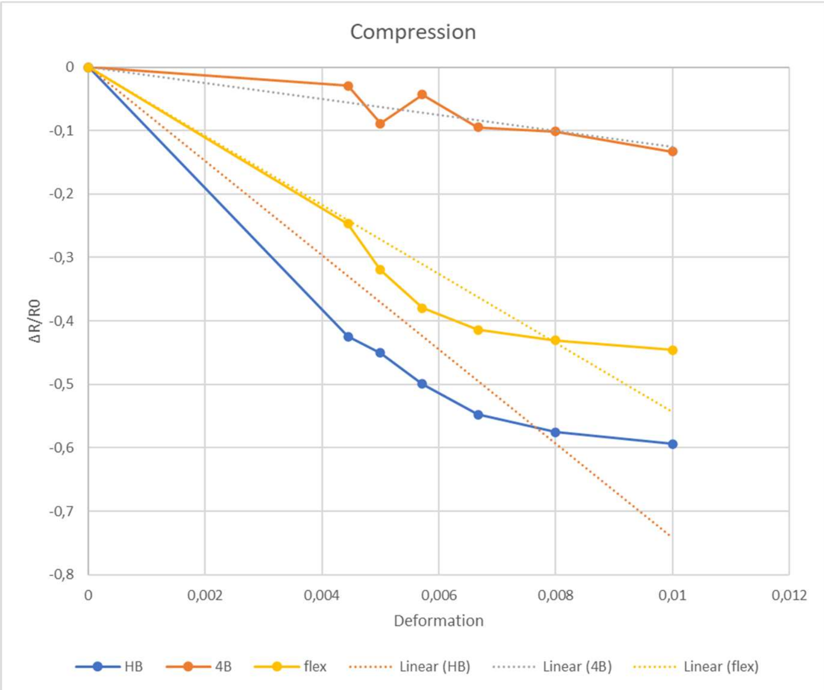
Characteristic graphs



The graphs above show the relative change in the sensor's value corresponding to deformation in two modes: tension and compression. Linear regression lines passing through the origin have been drawn. These theoretical lines demonstrate that the $\Delta R/R_0$ value changes linearly with deformation.

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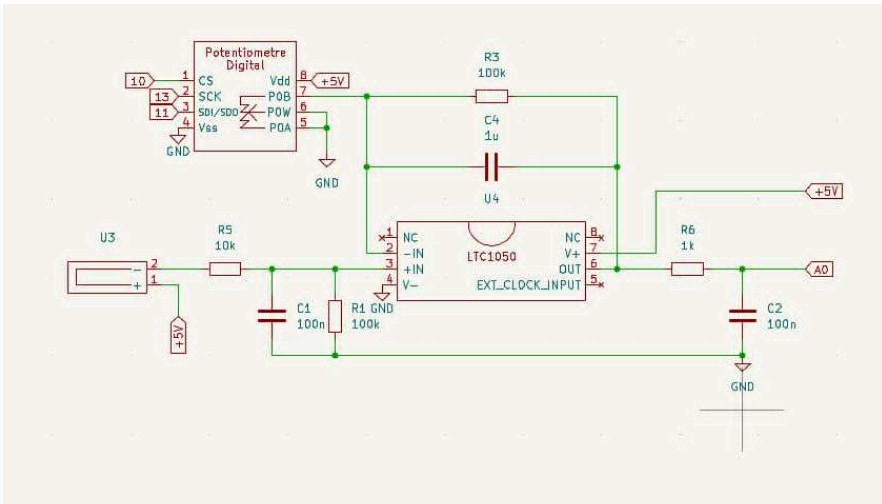
Typical Applications

A typical application of the sensor is shown in the analog circuit diagram, which uses a transimpedance amplifier to convert an input current signal into a voltage output signal.



The circuit includes three filtering stages:

- Input stage (R_1C_1): A low-pass filter with a cutoff frequency f_1 removes current noise from the input signal $f_1 = \frac{1}{2\pi R_1 C_1} = 16\ \mathrm{Hz}$
- Intermediate stage (R_3C_4): Another low-pass filter with a cutoff frequency f_2 filters out the 50 Hz noise component originating from the power grid $f_2 = \frac{1}{2\pi R_3 C_4} = 1.6\ \mathrm{Hz}$
- Output stage (R_6C_2): A final low-pass filter with a cutoff frequency of 1.6 kHz reduces noise introduced during ADC sampling $f_3 = \frac{1}{2\pi\ {}_6 C_2} = 1.6\ \mathrm{Hz}$

The C_3 capacitor filters out fluctuations in the amplifier's supply voltage. The R_2 resistor is used to calibrate the amplifier's output to match the voltage range of the microcontroller's ADC. A digital potentiometer was used during the prototyping phase to determine the optimal value of R_2. Lastly, the R_5 resistor provides electrostatic discharge (ESD) protection for the transimpedance amplifier and, together with C_1, forms an RC filter to suppress voltage noise.

Materials used:

$R_1 = R_3 = 100\ \mathrm{k\Omega}$, $R_5 = 10\ \mathrm{k\Omega}$, $R_6 = 1\ \mathrm{k\Omega}$, $C_1 = C_2 = 100\ \mathrm{nF}$, $C_4 = 1\ \mu\mathrm{F}$, LTC1050

The resistance obtained from graphite sensor depends on the potentiometer's resistance:

$$R_{gs} = \left(1 + \frac{R_3}{R_{pot}}\right) \times R_1 \times \frac{V_{CC}}{V_{ADC}} - R_1 - R_5$$