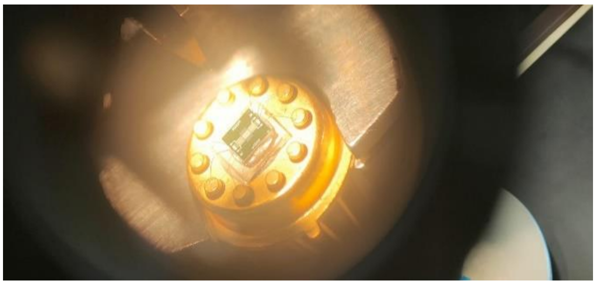
Low Power Gas Sensor based on tungsten trioxide nanoparticles.



Main features

- Dependable
- High sensitivity and selectivity
- User-friendly
- Minimal Power requirements
- Low cost
- Compact dimensions
- Extended lifespan
- Short response time
- Integrated temperature sensor
- Integrated heater

- Detect several gases:
    - Nitrogen dioxide (NO_2)
    - Carbon monoxide (CO)
    - Hydrogen sulfide (SO_2)
    - Dihydrogen (H_2)
    - Methane (CH_4)
    - Alcohols (-OH)
    - Ammoniac (NH3)

Description

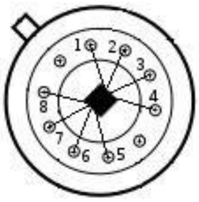
As part of the INSA Toulouse Innovative Smart System curriculum, we have developed a gas sensor utilizing tungsten trioxide nanoparticles. The sensing component comprises a silicon substrate, an integrated heater created from metal oxide semiconductor (doped polysilicon), and intricately designed aluminum elements, including a temperature-sensitive resistor and gas-sensitive elements with integrated tungsten trioxide nanoparticles. Upon contact with detectable gas molecules, the conductivity of these sensitive elements undergoes modification. The change in conductivity is dependent on the concentration and type of gas present. An external electronic circuit can be employed to detect and quantify these variations, thereby determining the nature and concentration of the gas (or gas blend).

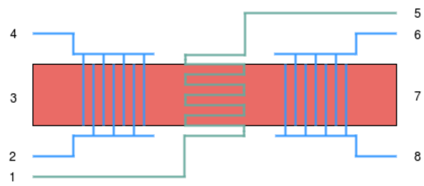
Furthermore, the integrated heater allows for the adjustment of sensitivity and selectivity, while a built-in temperature sensor monitors the temperature of the active zone. Due to its high resistivity, this sensor operates with minimal power consumption, requiring only several mA. It boasts reliability, high sensitivity even at low concentrations.

Specifications

Type	Chemical sensor
Sensing principle	MOS type
Composition	∘Silicon ∘N-Doped polysilicon ∘Aluminum ∘Tungsten trioxide nanoparticles
Power supply requirement	Active sensor
Nature of output signals	Analog
Measurement (Gas)	Resistance
Measurement (Temperature)	Resistance
Package	10-Lead TO-5 metal
Head diameter	< 9.5 mm
Head height	< 4.7 mm
Package height	< 25 mm
Pin diameter	< 0.6 mm
Mounting	Through hole fixed
Detectable gases	∘Nitrogen dioxide (NO_2) ∘Carbon monoxide (CO) ∘Hydrogen sulfide (SO_2) ∘Dihydrogen (H_2) ∘Methane (CH_4) ∘Alcohols (-OH) (ethanol C_2H_6O)
Typical detection range	> 1ppm
Typical response time	< 10 s
Typical recuperation time	> 60 s
Service temperature range	-30°C to 60°C
Typical applications	∘Air quality monitoring ∘Detections of toxic gases and contaminants

Pins configuration





Pin number	Usage
1 & 5	Temperature sensor utilizing an aluminum resistor
2 & 4	Gas Sensor 1 with WO3 nanoparticles on aluminum combs.
6 & 8	Gas Sensor 2 with WO3 nanoparticles on aluminum combs.
3 & 7	Heater Resistor

Precaution ⚠ :

- This sensor must not be used as a critical element because of injury risks in case of malfunctioning .
- Calibration is needed before using this sensor because of a high disparity in product.

Standard Test Conditions and Electrical Specifications at STC

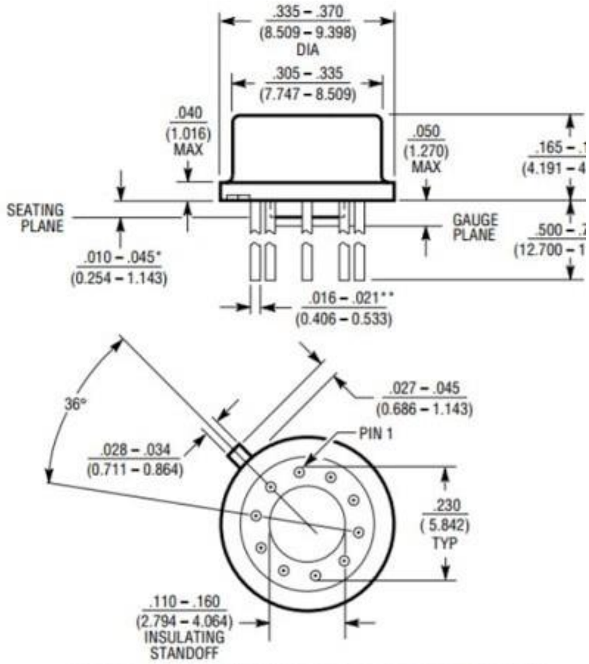
Standard test conditions	Air quality	%N2/O2	80/20
	Temperature	°C	20±2
	Humidity	%	60±5
Typical electrical characteristics under standard test conditions	Gas Sensor resistance	MΩ	1 - 20
	Temperature sensor resistance	Ω	60 - 75
	Heater resistance	Ω	120 - 150
	Gas sensor voltage	V	5
	Temperature sensors voltage	V	5
	Heater voltage	V	10 - 20

Environmental Performance

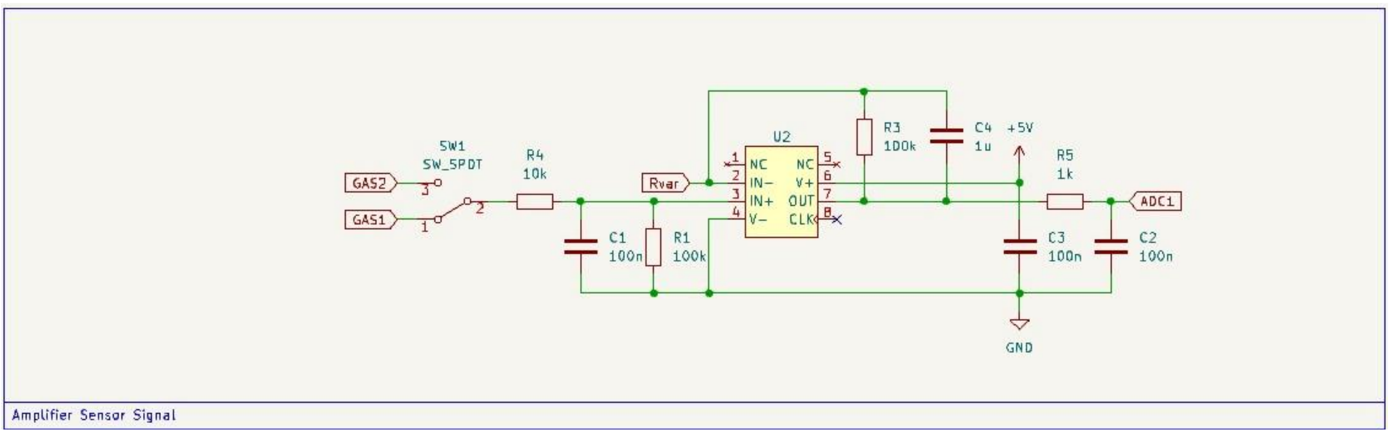
In an oxidizing environment, the gas sensor demonstrates an increase in resistance, while in a reducing environment, it exhibits a decrease in resistance. Notably, a higher gas sensor voltage corresponds to advantageous characteristics such as lower noise detection, reduced initial resistance, limited resistance excursion, and increased power consumption.

Moreover, an elevated temperature sensor voltage enhances measurement precision but contributes to higher power consumption. Additionally, an increase in heater voltage results in elevated temperatures in sensitive areas, heightened sensitivity, increased power consumption, and a trade-off with selectivity.

Structure and dimensions



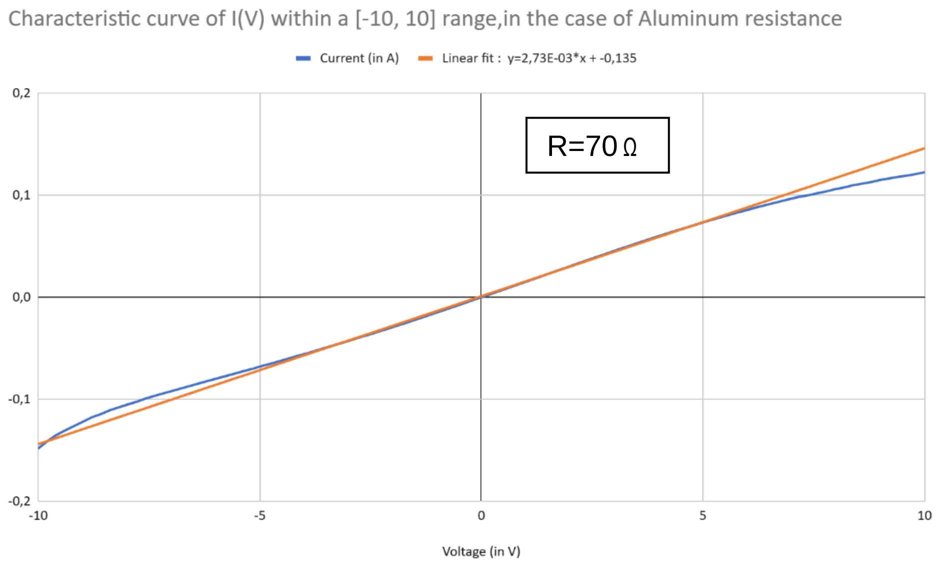
Examples of integration

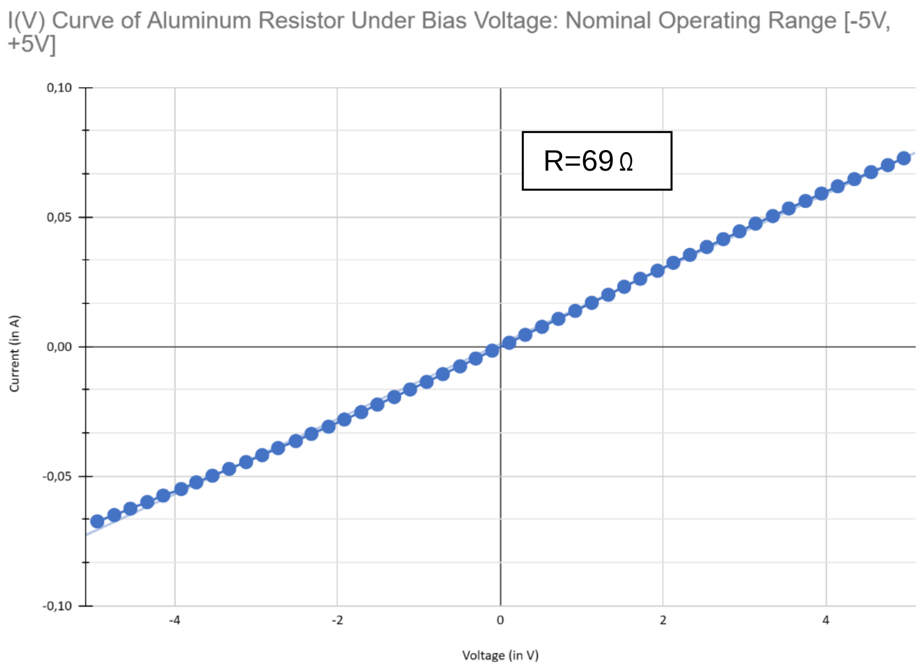


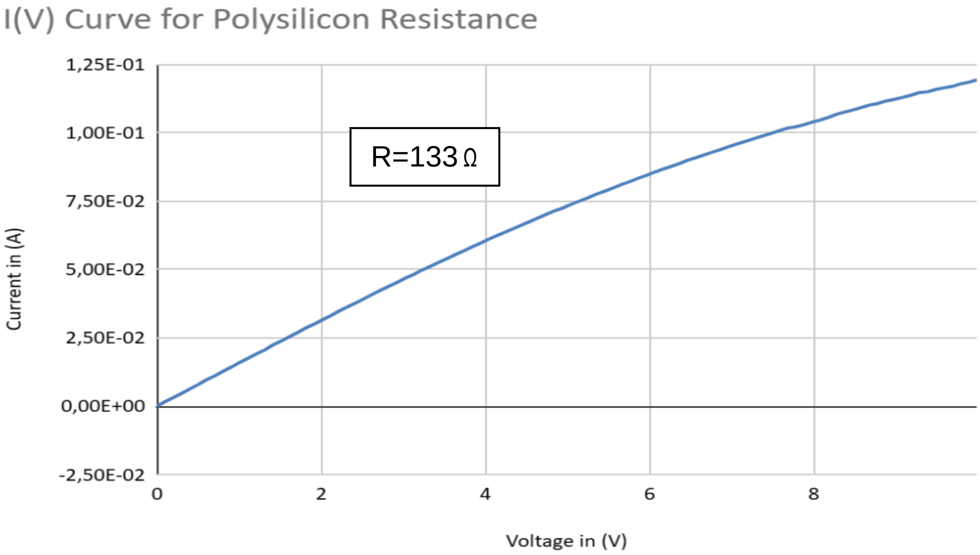
Here is an illustration of an integration circuit employed to connect the gas sensor to an Arduino. The operational amplifier transforms and amplifies a current that is proportionate to the resistance of the gas-sensitive element.

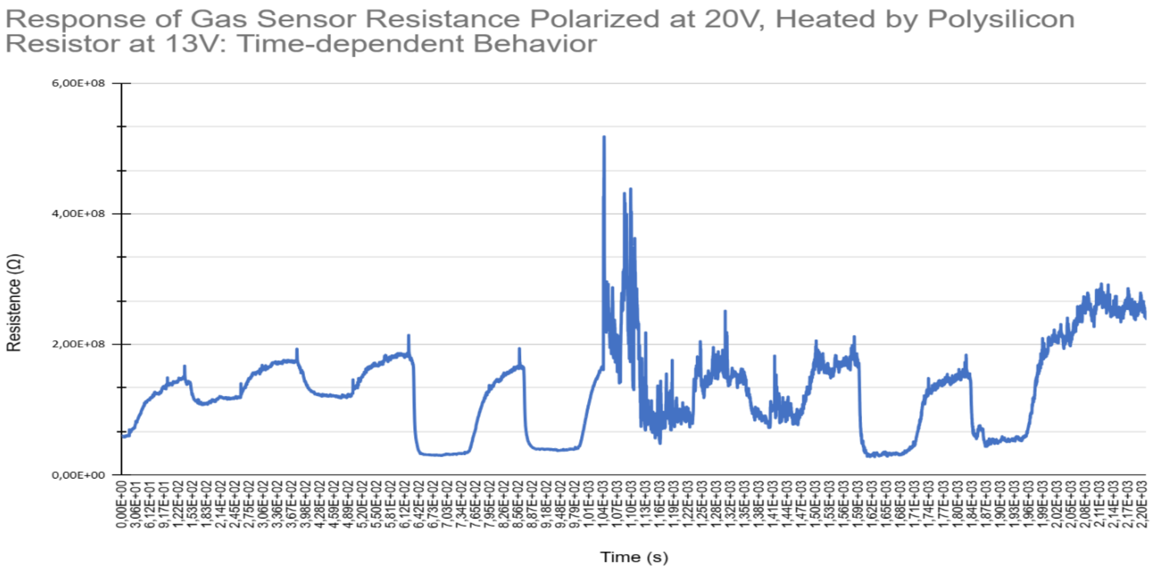
It is recommended to avoid introducing high voltage fluctuations to safeguard the sensor's integrity, especially in the event of a thermal shock where the aluminum area may detach.

Graphs depicting resistances and currents under standard test conditions.






I(V) Curve for Polysilicon Resistance
R=133 Ω
Current in (A)
1,25E-01
1,00E-01
7,50E-02
5,00E-02
2,50E-02
0,00E+00
-2,50E-02
0
2
4
6
8
Voltage in (V)


Response of Gas Sensor Resistance Polarized at 20V, Heated by Polysilicon Resistor at 13V: Time-dependent Behavior
Resistence (Ω)
6,00E+08
4,00E+08
2,00E+08
0,00E+00
Time (s)