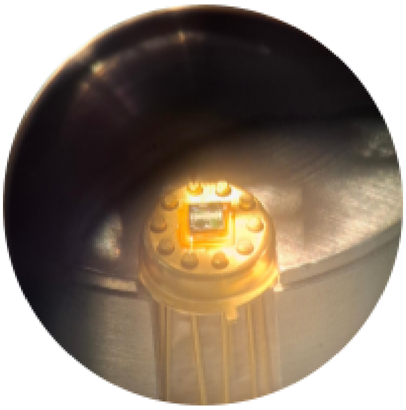
INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Pôle CNFM de Toulouse

Gas sensor based on tungsten trioxide (WO_3) nanoparticles

I. Features



- Low power consumption
- Easy-to-use
- Small size
- Low cost
- Detection of multiple gases: N_2/O_2, Ethanol (CH_3CH_2OH), Methane (CH_4)
- Integrated temperature sensor (Aluminium resistor)
- Integrated heater (Polysilicon resistor)

II. Description

This gas sensor is designed for monitoring air quality and detecting specific gases. It is based on tungsten trioxide (WO_3) nanoparticles. The sensor includes a heater and a temperature sensor, allowing measurement of the operating environment.

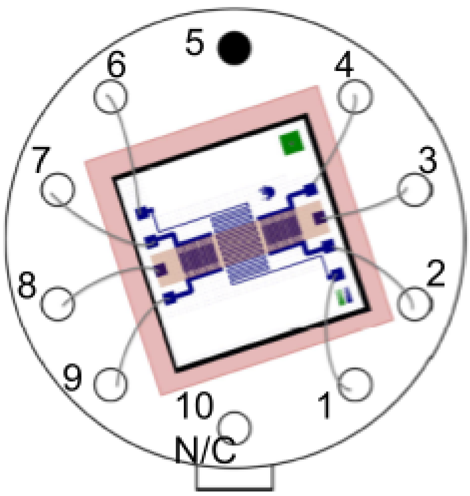
III. Specifications

Parameter	**Value/Description**
Type	Nanoparticle gas sensor (based on WO_3 nanoparticles)
Sensing principle	By resistance variation
Materials	Silicon, Aluminium, Polysilicon, Tungsten trioxide (WO_3)
Power supply requirement	12V for heating resistors, 5V for Gaz sensors resistors
Nature of output signals	Analog signal (resistance variation)
Nature of measurands	Resistance (GΩ range)

Package	10-Lead TO-5 metal can and cap
Diameter	8mm
Height	21mm
Mounting	Through-hole or surface-mount (depending on application)
Detectable gases	N_2/O_2, Ethanol (CH_3CH_2OH), Methane (CH_4)
Typical applications	Air quality monitoring, IoT smart objects, Safety (leak detection), Environmental monitoring

IV. Pins configuration

Pin number	Usage
4	Thermistor
9	Thermistor
6	Gas sensor resistor 1
8	Gas sensor resistor 1
1	Gas sensor resistor 2
3	Gas sensor resistor 2
2	Heating resistor
7	Heating resistor
5, 10	Not Connected



V. Standard use condition

	Unit	Typical Value

Temperature	°C	20
Humidity	%	50
Air quality	% N2/O2	80/20

VI. Electrical characteristics

	Unit	Value		
		Min	Typical	Max
Gas sensor resistance	**GΩ**	10	20	40
Temperature sensor resistance	**Ω**	-	75	-
Heater resistance	**Ω**	-	90	-
Gas sensor voltage	**V**	-	5	-
Heater	**V**	10	12	20

VII. Gas sensor resistance characteristics

The sensor's resistance varies significantly in response to different gases at specific operating temperatures. Below are the typical resistance dynamics observed at 150°C, 250°C, and 350°C for O_2, Ethanol (CH_3CH_2OH), and Methane (CH_4).

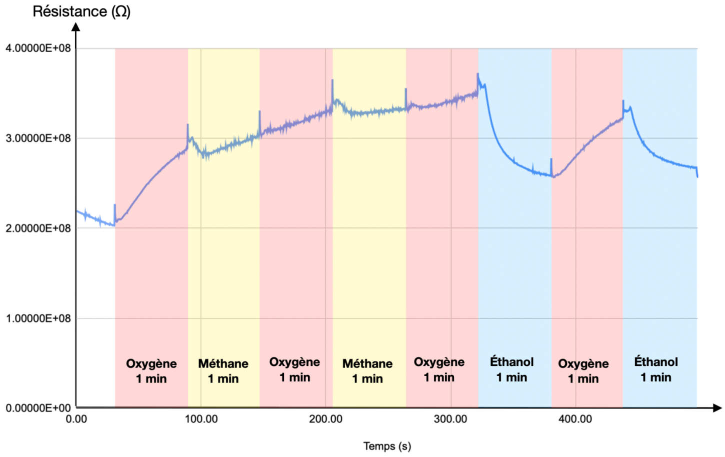


Figure 1. Resistance dynamic at 150°C

The resistance increases and stabilises during exposure to Oxygen and Methane, with sharp peaks for Ethanol. Ethanol causes a significant resistance spike, making it easily distinguishable from Oxygen and Methane.

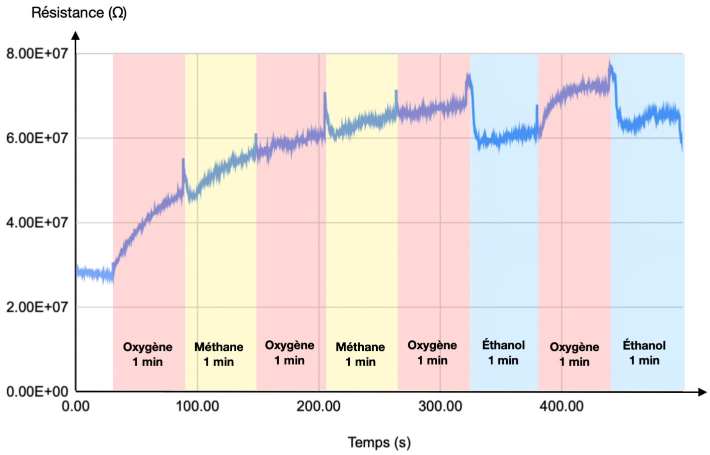


Figure 2. Resistance dynamic at 250°C

Resistance levels are lower compared to 150°C, with clearer separation between Oxygen, Methane, and Ethanol. Ethanol still causes a pronounced spike, but the baseline resistance is reduced, improving sensitivity.

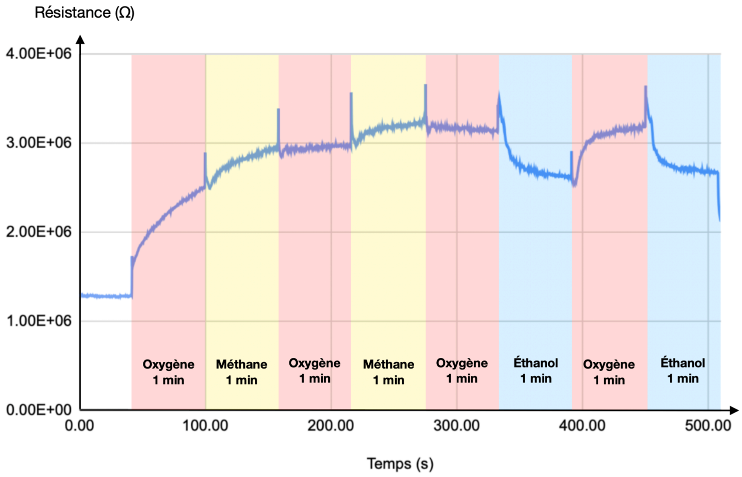


Figure 3. Resistance dynamic at 350°C

Resistance is further reduced, and the distinction between gases becomes more pronounced. Ethanol and Methane cause distinct resistance changes, while Oxygen remains stable.

VIII. Typical application

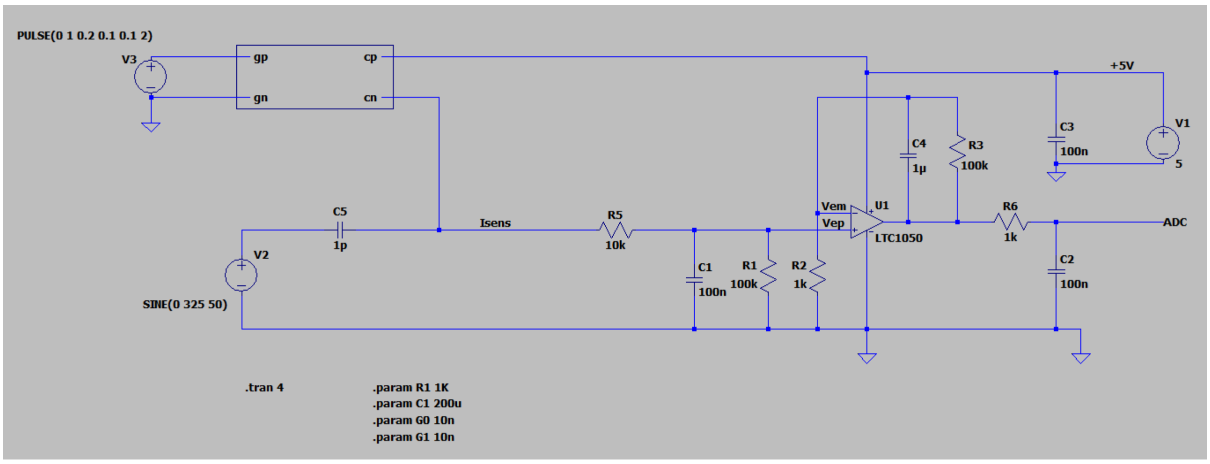


Figure 4: Example Application Circuit for WO_3 Gas Sensor

To use this sensor as a smart sensor, follow the circuit in Figure 4. Higher temperatures (e.g., 350°C) improve sensitivity and reduce baseline resistance, making gas detection more accurate. The key steps are:

- Power the sensor with a PWM AC source (e.g., V1) to control the heater and minimise power consumption.
- Condition the signal using an amplifier (e.g., LTC1050) with resistors (R4, R7, R8, R9, R10) and capacitors (C5, C6, C7, C8) to filter noise.
- Connect the output to an ADC for digital processing.
- Use a microcontroller to:
  - Adjust heater temperature via PWM.
  - Read ADC values and convert them to gas concentration.
  - Trigger regeneration if the sensor saturates.

Name	Description
V3	PWM AC source to power and control the heater.
V2	AC signal source to simulate sensor input for testing.
V1	+5V DC power supply for the amplifier and ADC.
R1	100kΩ resistor, part of the amplifier feedback network.
R2	1kΩ resistor, part of the amplifier feedback network.
R3	100kΩ resistor, connected to the non-inverting input of the amplifier.
R5	10kΩ resistor, used for current sensing (Isens).
R6	1kΩ resistor, part of the output stage of the amplifier.
C1	200nF capacitor, used for noise filtering in the amplifier input stage.
C2	100nF capacitor, used for noise filtering at the amplifier output.
C3	100nF capacitor, used for decoupling the +5V power supply.
C4	1µF capacitor, used for stabilizing the amplifier reference voltage.
C5	1pF capacitor, used for filtering high-frequency noise in the sensor input.
U1	LTC1050 operational amplifier, used for amplifying the sensor signal.

Isens	Current sensing node for monitoring heater current.
ADC	Analog-to-Digital Converter input, for digital processing of the sensor signal.