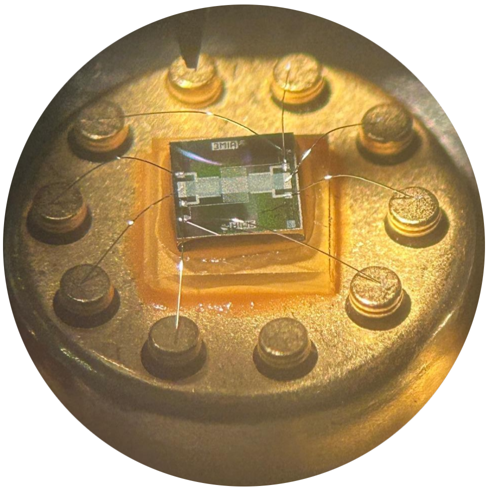
Low Power Gas Sensor based on tungsten trioxide nanoparticles

General features

- Low power consumption
- Easy-to-use
- Small size
- Low cost
- Short response time
- Detection of NH_3
- Detection of C_2H_6O
- Temperature sensor included
- Two integrated gas sensors
- Heater included (resistor)



Description

The GSWO3AIME is a multi-purpose metal-oxide (MOx) gas sensor developed at the AIME laboratory (Toulouse). It is based on a thin layer of tungsten trioxide (WO_3) nanoparticles deposited on a silicon substrate. The device integrates two identical gas-sensing elements (interdigitated electrodes) whose electrical resistance changes when target gas molecules interact with the WO_3 layer. As a result, the sensor's conductivity varies with both the type of gas and its concentration, enabling the detection of compounds such as ethanol, ammonia, water vapor, and other gases.

To ensure proper operation and stable measurements, the sensor includes an integrated heater implemented as a doped polysilicon layer, capable of raising the active area temperature up to approximately 300 °C. Temperature is monitored through an integrated metal resistor (e.g., an aluminium thermoresistor) whose impedance varies with temperature, providing feedback for closed-loop thermal control. In practice, both the gas-sensing element and the temperature sensor can be modeled primarily as variable resistances (capacitance variations are negligible), which allows straightforward readout using simple analog conditioning circuits (e.g., divider bridges). By controlling the operating temperature, the sensor's sensitivity and selectivity can be adjusted to emphasize different gas responses. The device is packaged in a 10-lead TO-5 metal can and, thanks to its high resistivity, typically requires only a few milliamps during operation.

Technical specification

2.1 Absolute maximum rating

	Min	Max	Unit
$U_{barreau}$ (poly-silicium heating element supply voltage)		10	V
U_{temp} (thermistor voltage)		7	V
T_{MOx} (Metal oxide resistor (Tungsten trioxide) temperature)		300	°C

2.2 Electrical Characteristics

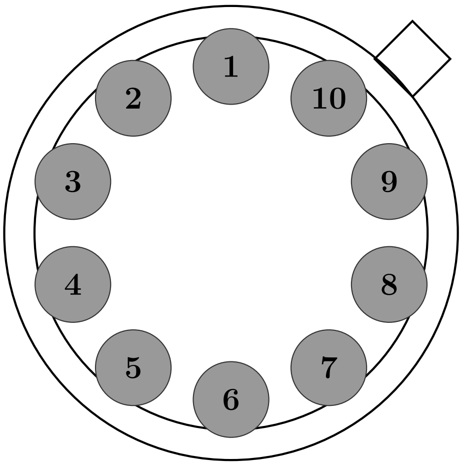
All measures have been done in an ambient environment at $T_{ambient} = 21°C$.

Parameter	Test Conditions	Min	Typ.	Max	Unit
Temperature sensor (Aluminium thermistor)					
R_{temp}	$U_{temp} = 10\,V$	80	86	94	Ω
S_{temp}	$U_{temp} = 10\,V$		1		Ω/°C
Poly-silicium heating element					
R_{poly}	$U_{barreau} = 5\,V$	79	87	94	Ω
Tungsten trioxide element (gas sensor)					
R_{gas}	$T_{MOx} = 21°C$, gas = N2O2 (dry air)	10	16	20	GΩ
$\Delta R/R_0$	$T_{MOx} = 277°C$, gas = ethanol, $C_{eth} = 1000\,ppm$	35	64	237	%
k_{eth}	$T_{MOx} = 277°C$, gas = ethanol, $C_{eth} = 1000\,ppm$		0.34		ppm
t_{eth}	$T_{MOx} = 277°C$, gas = ethanol, $C_{eth} = 1000\,ppm$		88		s
S	$T_{MOx} = 277°C$, gas = ethanol, $C_{eth} = 1000\,ppm$		85000		Ω/ppm
S_{lim}	$T_{MOx} = 277°C$, gas = ethanol, $C_{eth} = 1000\,ppm$		38.3		ppm

Table 1: Electrical characteristics measured at $T_{ambient} = 21°C$.

Pinout

Figure 1: TO-5 10 bottom view



Pin	Signal
1	Temp+ (Positive terminal for the internal aluminium termistance)
2	Gas1+ (Positive terminal for the first gas sensor)
3	Barreau+ (Positive terminal for the internal heating element)
4	Gas1- (Negative terminal for the first gas sensor)
5	NC
6	Temp- (Negative terminal for the internal aluminium termistance)
7	Gas2+ (Positive terminal for the second gas sensor)
8	Barreau- (Negative terminal for the internal heating element)
9	Gas2- (Negative terminal for the second gas sensor)
10	NC

Typical Characteristics

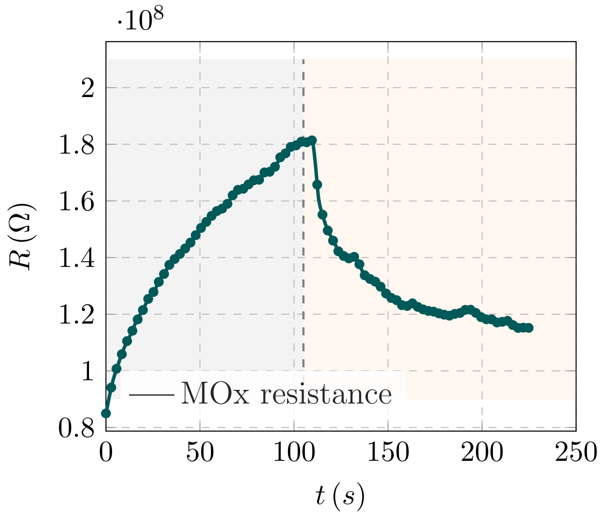


Figure 2: Evolution of the MOx resistance: regeneration phase (gray) without gas, followed by detection phase (orange). ($T_{MOx} = 277°C$, gas = ethanol vapor.)

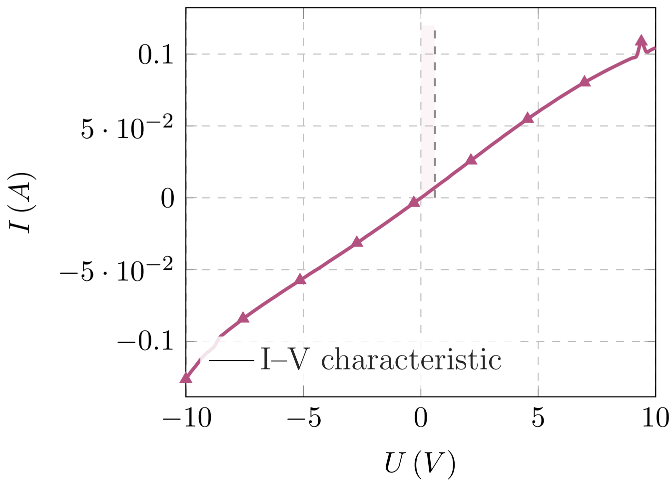


Figure 3: Thermistor I–V characteristic at $T_{ambient} = 21°C$, highlighting non-linear behavior at higher operating range.

Typical Application

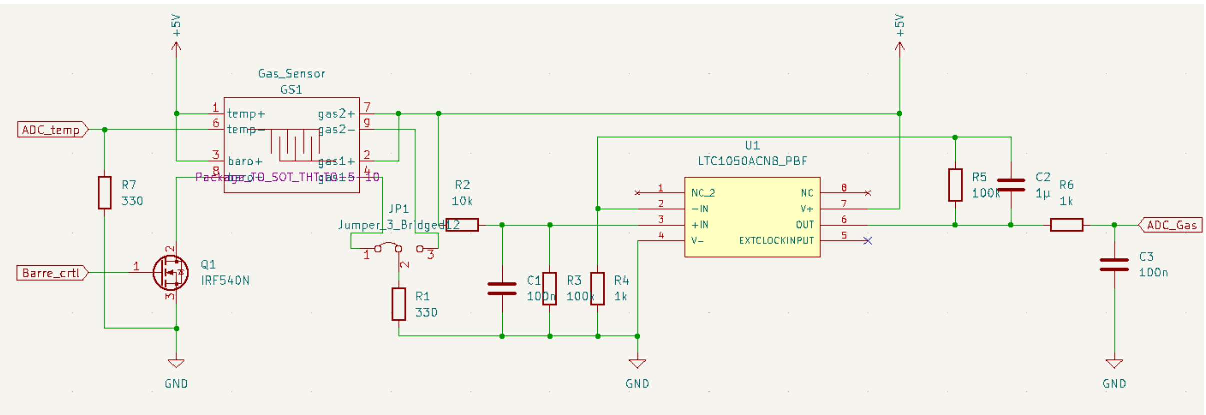


Figure 4: Typical application, electronic circuit schematic for conditionning the MOx resistor, the thermistor, and controlling the heating element.

Above is a typical application of the sensor in an analog circuit. One of the MOx gas-sensing elements is connected as a variable resistor in a voltage divider, together with the bias resistors, so that the divider output voltage follows the resistance change with gas concentration. This voltage is then conditioned by an LTC1050 operational amplifier and subsequently filtered by an RC low-pass stage to reduce noise and provide a stable signal. The resulting output, labeled ADC_Gas, can be connected directly to a 5 V ADC (for instance, a microcontroller or an Arduino). In parallel, the integrated temperature sensor is also used as a resistive element in a divider bridge, producing a voltage that can be digitized on ADC_Temp for temperature monitoring and compensation. Finally, the heater is supplied from a higher-voltage line and driven by a transistor stage, allowing the sensing element to be heated (up to around 10 V supply for the heater, depending on the operating mode) during the measurement cycle.

Important Notes

- Perform a calibration with the target gas prior to operation to ensure accurate concentration (ppm) readings.
- A regeneration phase is required under a non-oxidizing atmosphere to restore the sensing element between measurements.

Package Outline

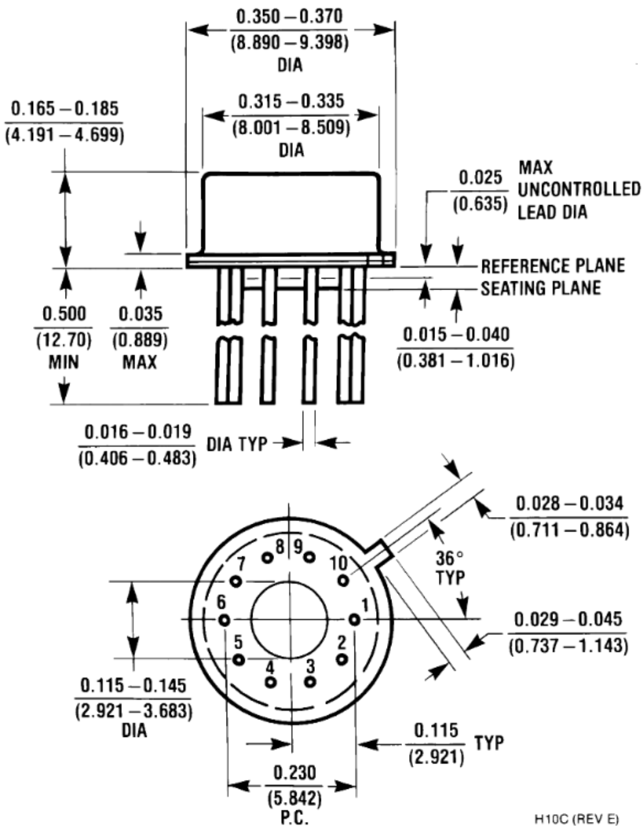


Figure 5: 10 Lead (0.230" Diameter P.C.) TO-5 Metal Can Package NS Package Number H10C