

# Gas sensor based on tungsten trioxide ( $\text{WO}_3$ ) nanoparticles

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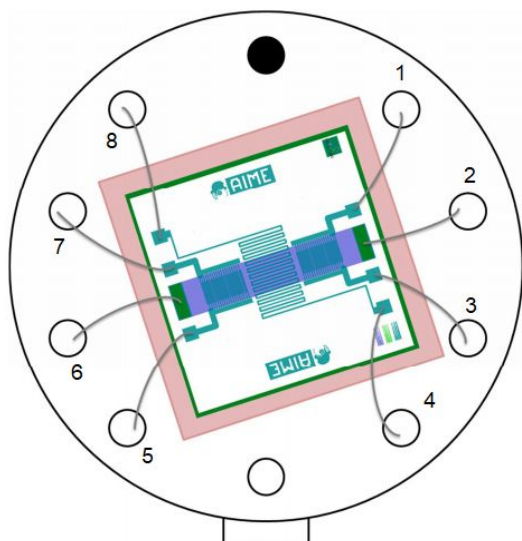
## Features of the sensor :

- Detection of  $\text{NH}_3$  (Ammonium hydroxide)
- Detection of  $\text{CH}_3\text{CH}_2\text{OH}$  (Ethanol)
- Quick response
- Heater resistor included (Polysilicon)
- High impedance
- Temperature sensor (Aluminium)

## Description :

This gas sensor allows us to monitor the amount of gases (Ammonium hydroxide, Ethanol and air) . It was manufactured in the AIME local at INSA Toulouse. It is based on a nanoparticle: the tungsten ( $\text{WO}_3$ ), a doped polysilicon heater, and aluminium resistors where the tungsten is integrated. Consequently, depending on the amount of gas, the conductivity of the resistance variation enables the computation of the concentration of gas thanks to an external electronic circuit.

## Pin Description and functions



Pin Number	Usage
1 - 3	Gas sensor (WO <sub>3</sub> nanoparticles integrated on interdigital aluminium combs)
2 - 6	Heater (Doped Polysilicon)
5 - 7	Gas sensor (WO <sub>3</sub> nanoparticles integrated on interdigital aluminium combs)
4 - 8	Temperature sensor (Aluminium resistor)

## Specifications

<b>Type</b>	Nanoparticle based sensor
<b>Materials</b>	<ul style="list-style-type: none"> <li>• Silicon</li> <li>• Doped polysilicon</li> <li>• Aluminium</li> <li>• Tungsten trioxide nanoparticle</li> </ul>
<b>Sensor type</b>	Active sensor
<b>Nature of output signal</b>	Analog signal
<b>Nature of measurand</b>	Resistance mesure
<b>Detectable gaz</b>	<ul style="list-style-type: none"> <li>• NH<sub>3</sub> (Ammonium hydroxide)</li> <li>• CH<sub>3</sub>CH<sub>2</sub>OH (Ethanol)</li> </ul>
<b>Mounting</b>	Through hole fixed
<b>Response time</b>	< 30s
<b>Recuperation time</b>	> 100s
<b>Nominale temperature</b>	[423K - 573K]
<b>Deterioration temperature</b>	573K +

## Physical Characteristics

Package	Package 10-Lead TO-5 metal can
Diameter	10mm
Height	25mm

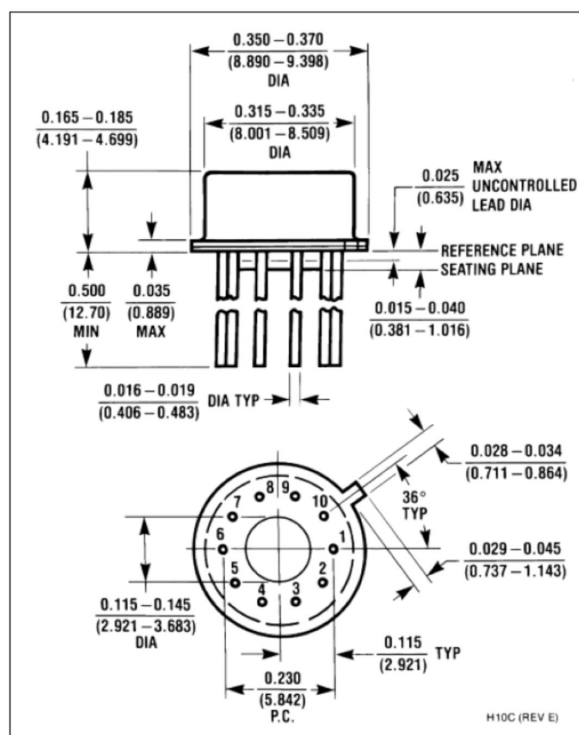
## Recommended Operating Conditions

Temperature	25°C+5°C
Pressure	101,325 Pa

## Electrical Characteristics

	Aluminum	Polysilicon
Nominal Use	0 - 5V	0 - 11V
Non Deterioration Use	5V - 10V	11V - 15V

## Dimensions



## Characteristic graphs of resistances and currents in standard test conditions

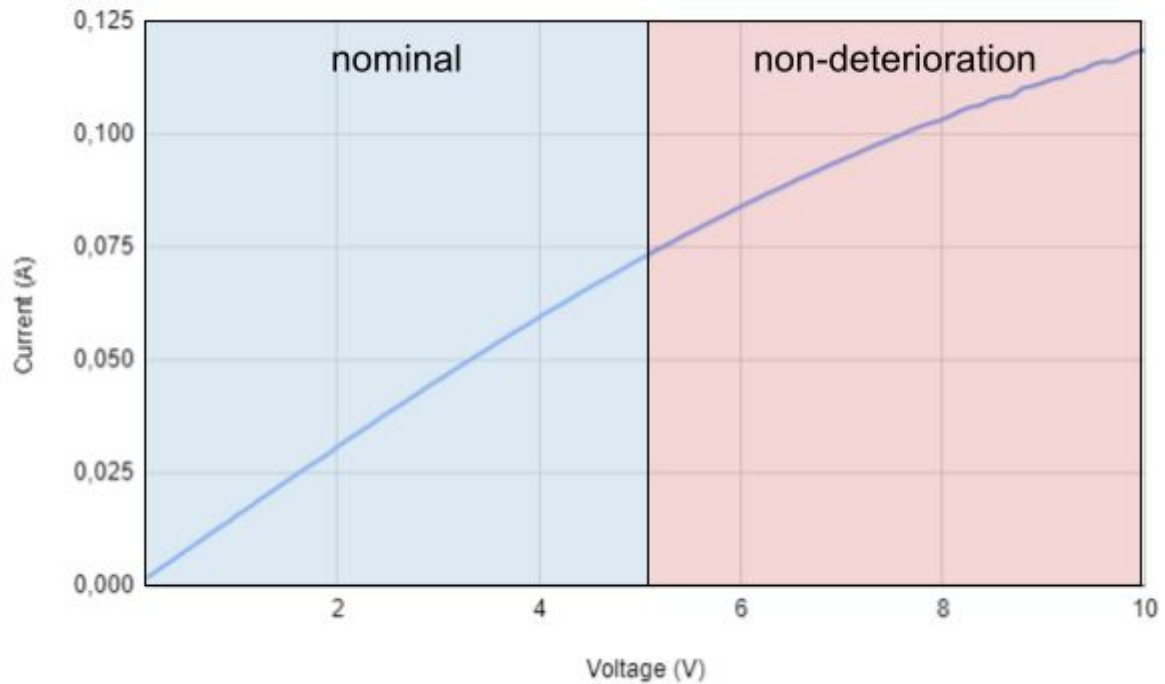


Figure1: Current and resistance response as a function of voltage (RESISTANCE ALU)

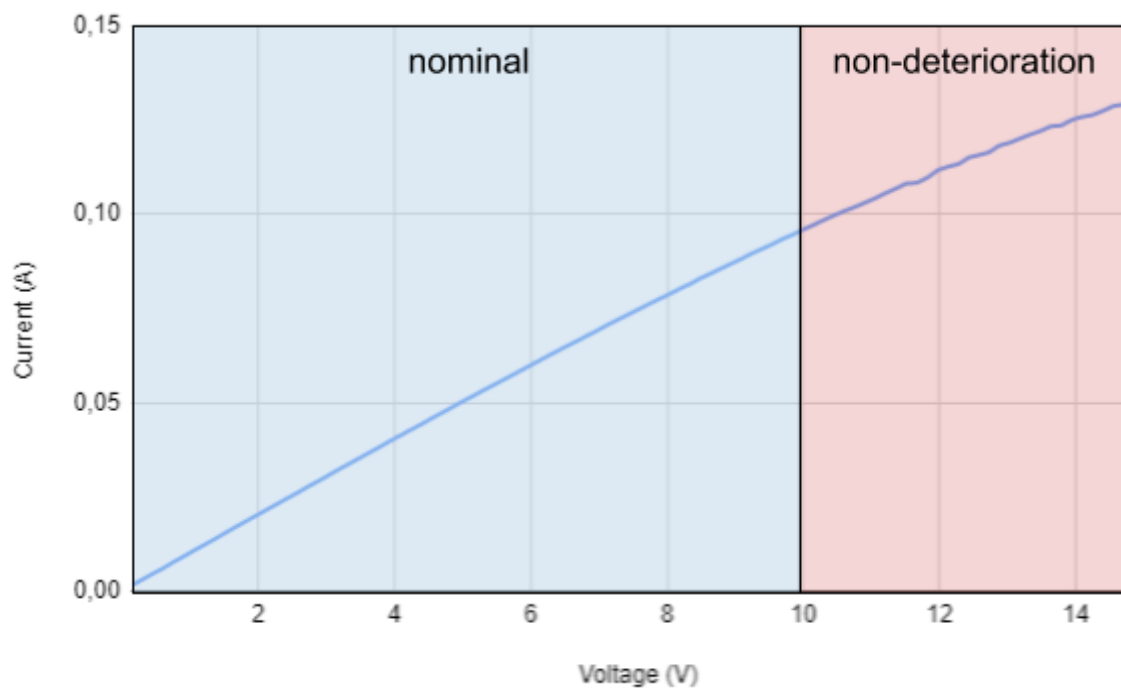


Figure2: Current and resistance response as a function of voltage (RESISTANCE POLYSILICON)

## Procedure for the characterization of the sensor

15s	120s	120s	120s	120s	120s	120s	120s	120s	...
Ø	Dry air	Ethanol 1000ppm	Dry air	Ethanol 1000ppm	Dry air	NH <sub>3</sub> 1000ppm	Dry air	NH <sub>3</sub> 1000ppm	Dry air

## Results at 523K

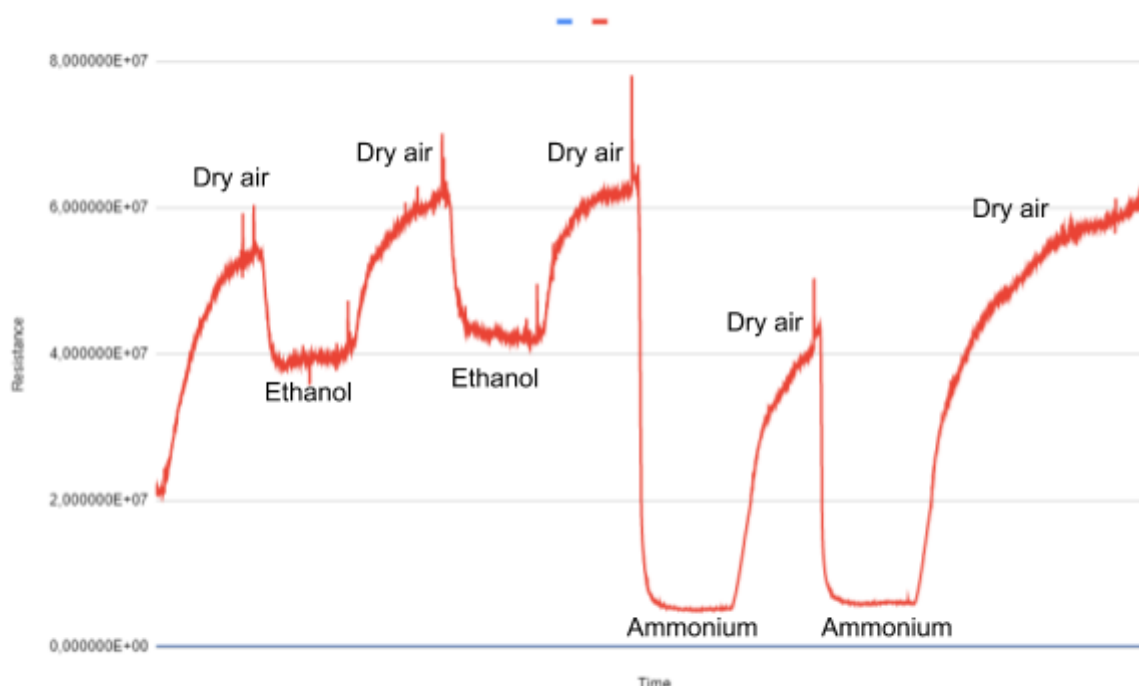


Figure3: Results at 523K, resistance response as a function of time

By measuring the resistance of the resistance, we outline the sensor characteristic. The first half of the test phase was the response under ethanol gas, while the last half was under ammonia. The drop in the resistance shows the gas sensor response to a given gas while the increase in resistance illustrates the process of rebuilding the sensor.

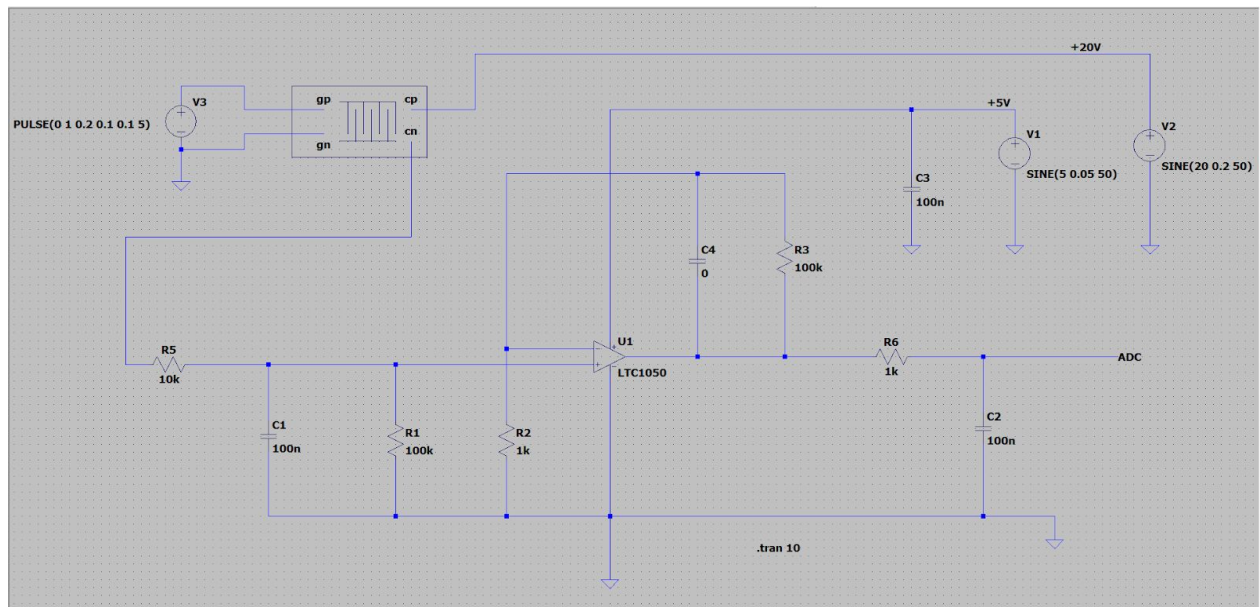
N <sub>2</sub> O <sub>2</sub>		CH <sub>3</sub> CH <sub>2</sub> OH		NH <sub>3</sub>	
DR/R0 (%)	kN <sub>2</sub> O <sub>2</sub> - tN <sub>2</sub> O <sub>2</sub>	DR/R0 (%)	kEth - tEth	DR/R0 (%)	kNH <sub>3</sub> - tNH <sub>3</sub>
-50%	0,1 Hz - 10s	-27,00%	0.04 Hz - 25s	-150,00%	0.167 Hz - 6s

Note : The response at 453K provides a more sensitive response than at 523K. The detection of a gas causes a more significant reaction with a better response time. However, the resistor reconstitution time is much longer and is not suitable for high frequency use.

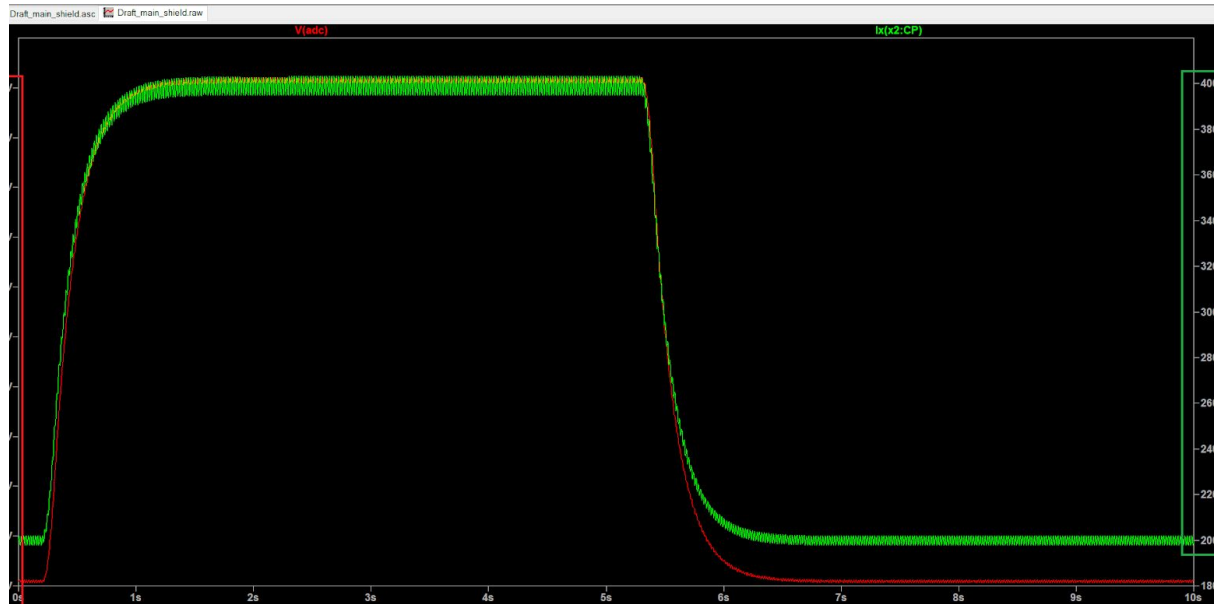
## Possible Conditioning Circuit for measurement with Arduino Uno

The entry impedance of the Arduino is much lower than the impedance of the Sensor. We must therefore put in place a conditioning circuit. This conditioning circuit is an amplifier that allows us to shape the sensor response to obtain an exploitable signal that our Arduino will take care of.

Here is below a possible circuit:



For input, we apply a PULSE signal with 5 seconds at HIGH LEVEL (1 digital) and we observe in output the VADC which is also the input voltage of our Arduino board.

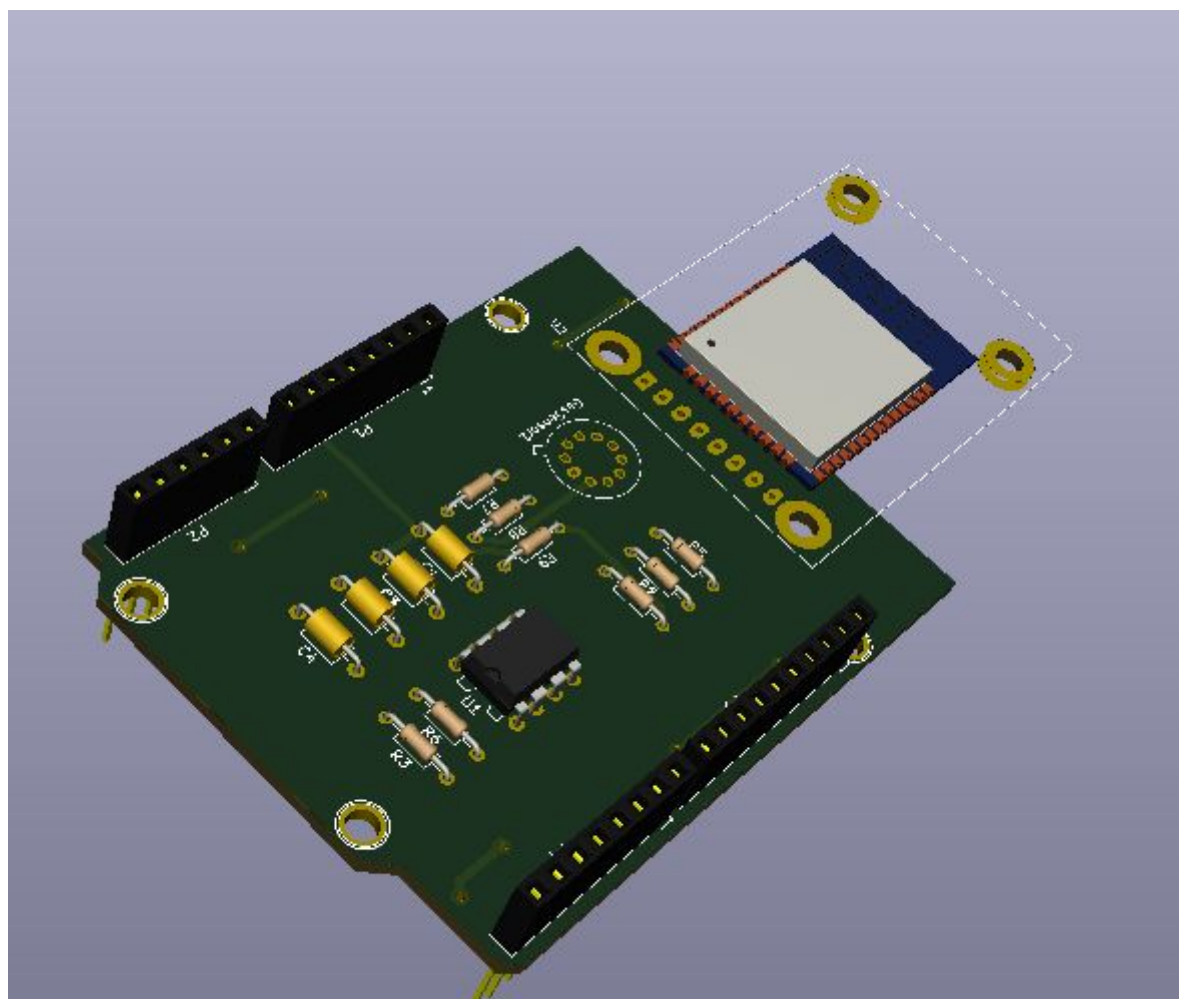
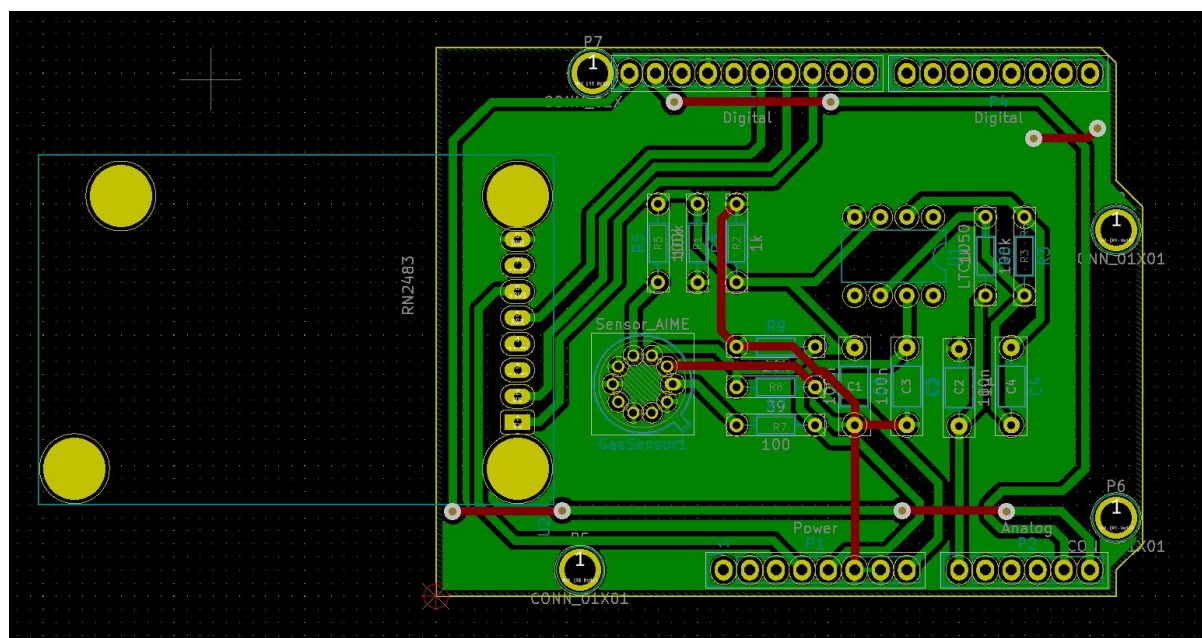


We observe that when  $I_x$  change its state from LOW to HIGH or HIGH to LOW,  $V_{ADC}$  also changes its state with a very small delay. For  $I_x$  varies from 200nA to 400nA, we obtain  $V_{ADC}$  varies from 2V to 4V, so the gain of our amplifier circuit equals to:  $10^7$  (V/nA)

The  $V_{ADC}$  signal (red) “follows” very well the evolution of our input signal ( $I_x$ ).



## KiCad shield for sensor integration



## Possible arduino code for usage

Arduino code for sensor reading, optimizing the energy consumption by putting on sleep the gas sensor when we don't need it.

```
#define debugSerial Serial

void setup(){
    debugSerial.begin(9600);
    pinMode(9,OUTPUT); //Sensor alim PIN
    pinMode(A0,INPUT); //Sensor output PIN
    while (!debugSerial && millis() < 10000)
        ;
}

void loop(){
    debugSerial.println("-- LOOP");
    digitalWrite(9,HIGH);
    delay(200);
    uint32_t tension = analogRead(A0); //Reading the gas level
    digitalWrite(9,LOW);
    delay(200);
    debugSerial.println("Mesure: " + String(tension));
    delay(1000);
}
```