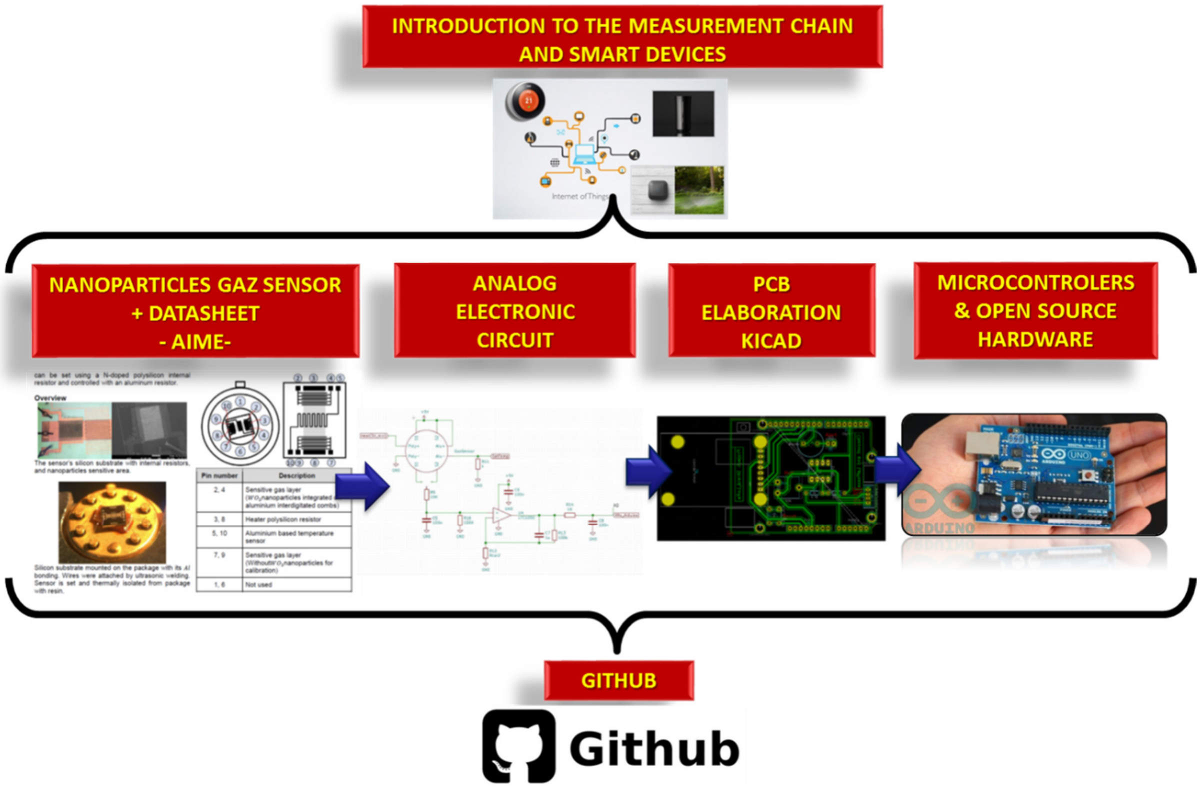
INSTRUCTIONS FOR THE UF "SMART DEVICES" – PTP ISS

The module entitled "SMART DEVICES" as part of the "Innovative Smart System" PTP includes, by starting order:

1. **A one week training period to develop a gas sensor based on nanoparticles (internship at AIME),**
2. **Some lectures and TD called "introduction the measurement chain and smart devices" to be followed online (SPOC version) and on-site,**
3. **Several practical works (TP) on Git and the GitHub platform**
4. **Several practical works (TP) related to the design of an analog circuit to interface the gas sensor produced to the AIME**
5. **Some lecture /TD/TP on microcontrollers and open source hardware**
6. **Some lecture/TP on the production of electronic cards under KiCad**

These items are described on the overall synoptic of the UF "Smart Devices":



Thanks to all these lessons, you will be able to achieve the final objective of the UF:

> **"Design and build a smart device based on the combination of a gas sensor and an electronic card to communicate data over a low speed network (through a LoRa connection *on for example The Thing Networks*)"**

Please note that all necessary resources are available on the UF Moodle:

- PTP ISS : https://moodle.insa-toulouse.fr/course/view.php?id=935#section-3

And

- MICROCONTROLEURS ET OPEN SOURCE HARDWARE : I5GPII11 - MICROCONTROLEURS ET OPEN-SOURCE HARDWARE : http://moodle.insa-toulouse.fr/course/view.php?id=494.

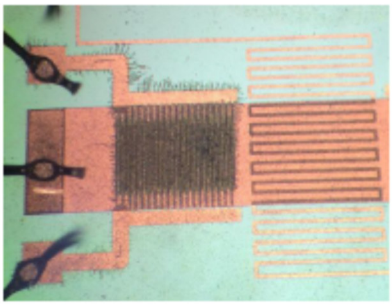
1.- A training period to develop a gas sensor based on nanoparticles (internship at AIME),

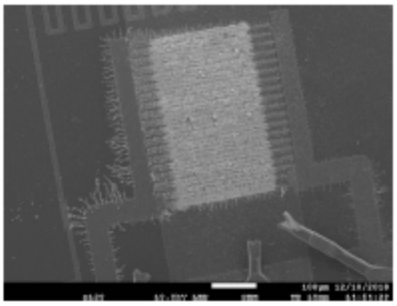
You will make a gas sensor that needs the synthesis of nanoparticles, the active zone of capture of nanoparticles, the deposition of nanoparticles by dielectrophoresis until the contact of the cell.

The internship will take place at AIME during week 45
Your schedule is detailed in the attached pdf file.

AIME informations:
https://www.aime-toulouse.fr/
Contact:
https://www.aime-toulouse.fr/acces-et-contacts/
Map:
https://www.openstreetmap.org/?mlat=43.572230795883&mlon=1.4671146401822&zoom=16#map=16/43.57220/1.46710

Overview





The sensor's silicon substrate with internal resistors, and nanoparticles sensitive area.

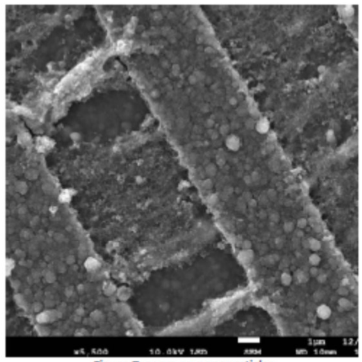
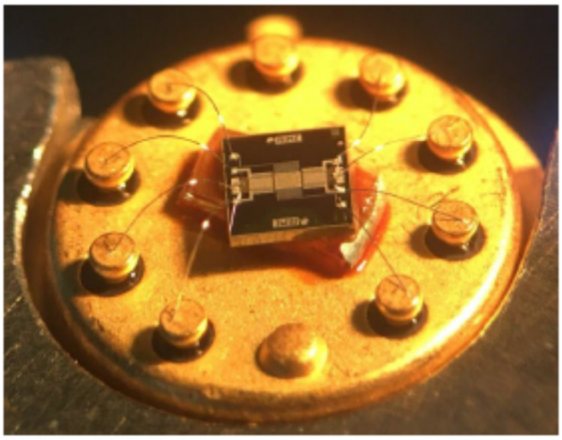


Figure 7: zoom on nanoparticles



And finally you will elaborate the datasheet sensor :

AiME Micro-Nano	Low-power high-efficiency tungstate nanoparticles gas sensor	AIME GASWO3A-2018 Datasheet

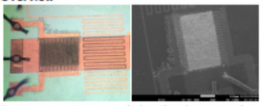
Description

The *AIME GASWO3A* sensor is a highly sensitive tungstate (WO_3) nanoparticles gas sensor, designed for detection of oxidable-gases in the air. It can detect gas such as (but not limited to) Ethanol and Ammonium.

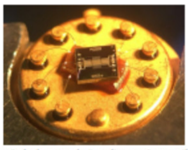
It is based on a metallic-oxide of tungsten trioxide nanoparticles set in aluminum interdigitated combs on a N-doped silicon substrate. Sensor contains two sensitive aluminum combs, one of which does not have a nanoparticles deposit and can be used for calibration purposes.

Reactivity of the metallic-oxide is factor of the temperature of the sensing area. Sensor temperature can be set using a N-doped polysilicon internal resistor, and controlled with an aluminum resistor.

Overview



The sensor's silicon substrate with internal resistors, and nanoparticles sensitive area.



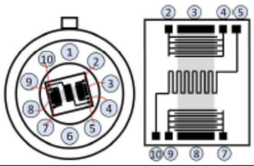
Silicon substrate mounted on the package with its Al bonding. Wires were attached by ultrasonic welding. Sensor is set and thermally isolated from package with resin.

Features

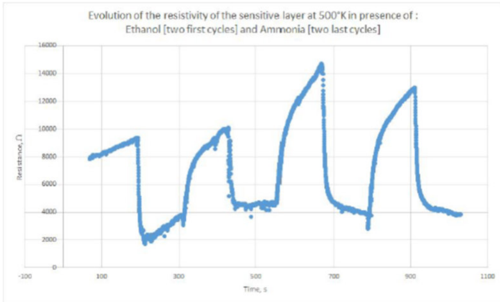
- High sensitivity to a wide range of gases
- State-of-the-art nanoparticles technology
- Conditioner is not integrated in the package: power efficiency can be optimized to the application
- Long lifetime
- Short to instant response-time
- Environmentally safe(ish)
- Low cost at high volume

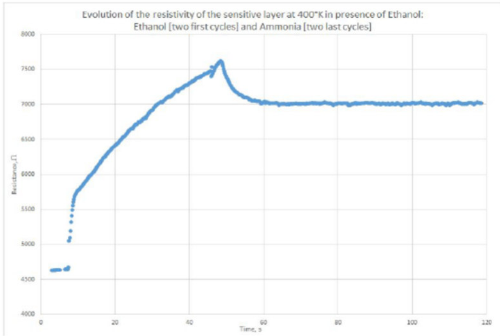
Packaging

Sensor is mounted on a 10-pin TO-5 package. It protected by a drilled enclosing cap that lets gas pass-through. Sensor and its bondings are sensitive and should be handled with care.



Pin number	Description
2, 4	Sensitive gaz layer (WO_3 nanoparticles integrated on aluminium interdigitated combs)
3, 8	Heater polysilicon resistor
5, 10	Aluminium based temperature sensor
7, 9	Sensitive gaz layer (Without WO_3 nanoparticles for calibration)
1, 6	Not used





2. “Introduction the measurement chain and smart devices” (to be followed online (SPOC version) + on-site):

You can access the SPOC version of the “introduction to sensors” courses at the following addresses:
I ask you to watch the videos before coming to class as noted in ADE planning:

1 - CM noted 1/7 "Introduction Sensors":

work on Introduction : https://moodle.insa-toulouse.fr/mod/resource/view.php?id=14443
and Chapter I: https://moodle.insa-toulouse.fr/mod/resource/view.php?id=14444

2 - CM noted 2/7 "Introduction Sensors":

work on Chapter II: https://moodle.insa-toulouse.fr/mod/resource/view.php?id=14445

3 - CM noted 3/7 "Introduction Sensors":

Work on Chapter III: https://moodle.insa-toulouse.fr/mod/resource/view.php?id=14446
We will perform exercises.

4 - CM noted 4/7 "Introduction Sensors":

work on Chapter IV: https://moodle.insa-toulouse.fr/mod/resource/view.php?id=14447
Work on Chapter V: https://moodle.insa-toulouse.fr/mod/resource/view.php?id=14448

5 - CM noted 5/7 "Introduction Sensors":

We will begin the datasheet.
Please come with all your sensor data so that we can build a common datasheet !!!

6 – CM noted 6/7 and 7/7 "Introduction Sensors":

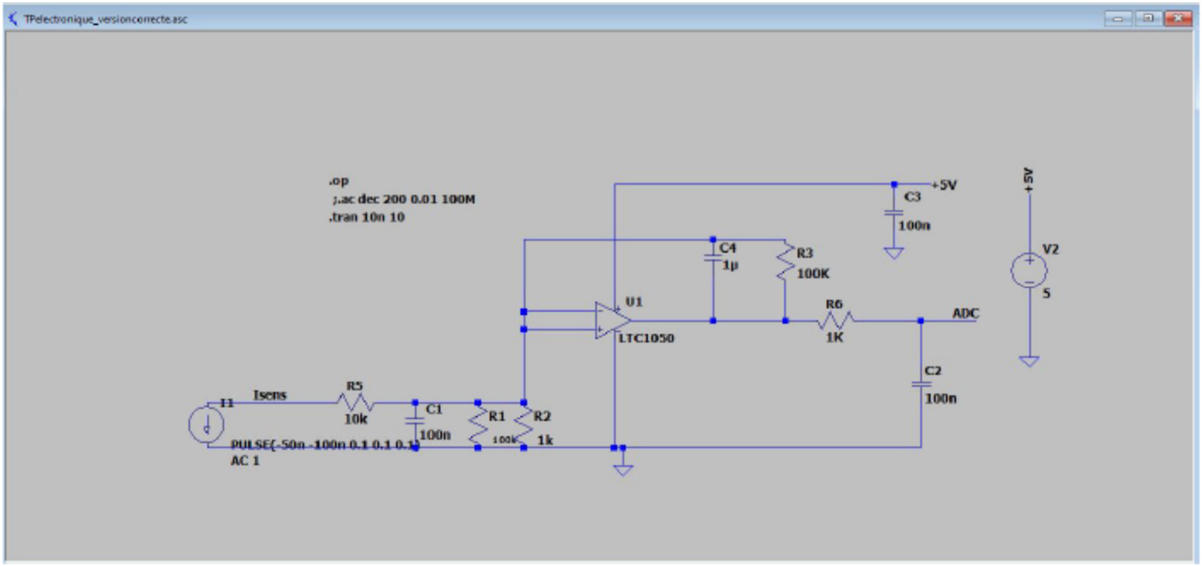
We will continue to work on the DATASHEET.
Please come with all your sensor data so that we can build a common datasheet !!!

Warning: just because the video only lasts 20 minutes, your personal work should not stop at the end of the video.

After viewing these courses online, we will have on-site restructuring TD sessions to do some exercises.

3.- TPs related to the design of an analog circuit to interface the gas sensor produced to the AIME:

The objective of this TP is to study the analog electronic, using the LTSpice IV software, dedicated to connect the sensor and measure its resistance. A special attention will be devoted to the low current circuit connected to the microcontroller and perform low-pass filtering to extract useful information from our gas sensor.
The below figure shows an example of our schematic diagram.



4.- a TP on Git and the GitHub platform

The pedagogy developed in this training unit is based on open source (hardware and software) and collaboration between engineers. Thus, throughout the course of the project, we propose to use a collaborative tool, GitHub platform, that will allow you to work together efficiently.
In these lectures, we will then introduce the GitHub online software devoted to the development of software and version control service.

Thus, in these lectures, you will gather all necessary information's to use the GitHub platform and to submit the documents that will be necessary for your evaluation.

[Introduction](#) to versioning with Git and sharing code on GitHub
Ressources : https://moodle.insa-toulouse.fr/course/view.php?id=494#section-6

5. - a course/TP on the production of electronic cards under KiCad

In addition, you will be able to review the KiCad course sessions filmed last year in the MOODLE section: INTRODUCTION AU PROTOTYPAGE RAPIDE DE PCB

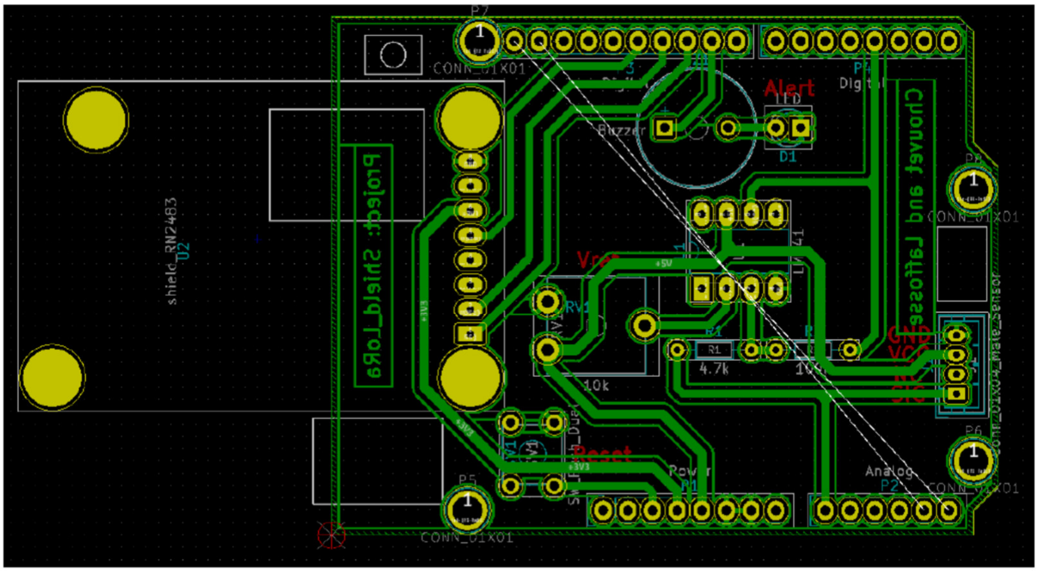
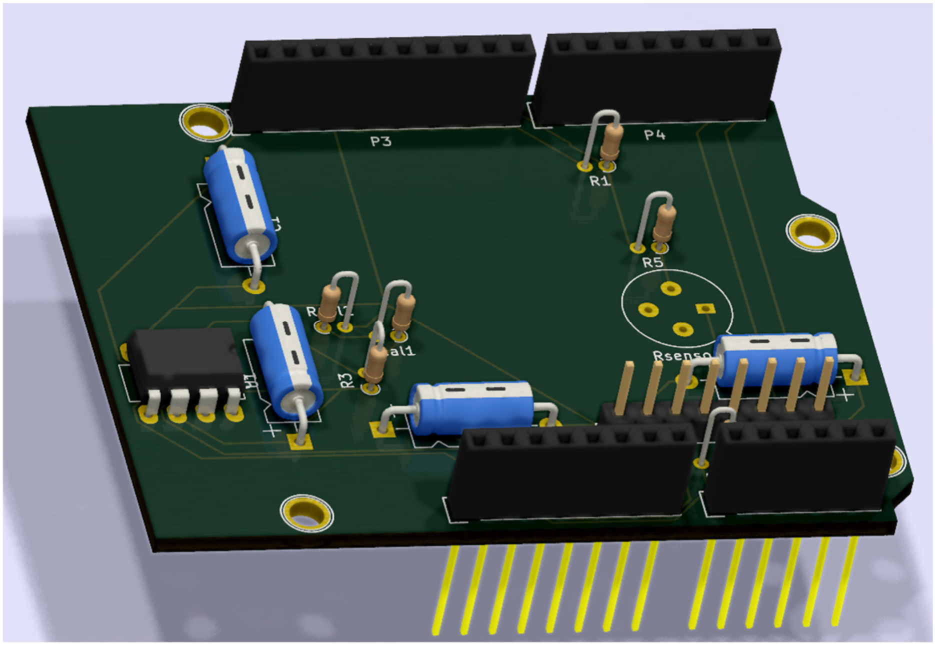


Figure 2.11: Electrical Circuit of the smart gas sensor on KiCAD



6.- a course/TD/TP on microcontrollers and open source hardware

These lectures will be devoted to the use of the Arduino® and ESP 32 platforms that will be used here as complete electronic development platforms that enable the creation of high-performance microcontroller-based applications at a lower cost.

The PTP ISS draws its strength from all your educational origins (GP, AE, IR, MSIOT...), at the same time it is not possible to bring you to the same level of skills. Our objective is therefore to increase your skills regardless of your initial skills.

This is why we suggest that you choose the pedagogical elements that you feel capable of following from among all the resources.

To make your choice, we have concocted a color code that will allow you to estimate the difficulty of the pedagogical element:

Green: very easy, suitable for beginners
Blue: easy to medium
Red: medium to difficult
Black: the most difficult

Depending on your skills in the field, we suggest you choose either:

1 - to carry out the TPs noted TP1 Program => TP5 Program

To do so, follow the following links:

https://moodle.insa-toulouse.fr/course/view.php?id=494#section-4
https://moodle.insa-toulouse.fr/course/view.php?id=494#section-5
https://moodle.insa-toulouse.fr/course/view.php?id=494#section-7
https://moodle.insa-toulouse.fr/course/view.php?id=494#section-8
https://moodle.insa-toulouse.fr/course/view.php?id=494#section-9

2 - to carry out in semi-autonomy, the mini-project LoRa below

To do so, follow the following link:

https://moodle.insa-toulouse.fr/course/view.php?id=494#section-10

Be aware that, whether it is the typical TP series or the mini-project, you will be able to choose the difficulty (green, blue, red, black...) that it seems affordable to you according to your initial skills.

Evaluation of the UF:

To validate the UF, we then propose you to proceed in THREE TIME!

You are free to use at any time, when it seems useful, the GitHub of the UF Smart Devices https://github.com/orgs/MOSH-Insa-Toulouse/ available for you.

To do this you will need to create an account on the GitHub platform at https://github.com/join and send your "Username" to Arnauld.Biganzoli@insa-toulouse.fr

1 - IN A FIRST STEP:

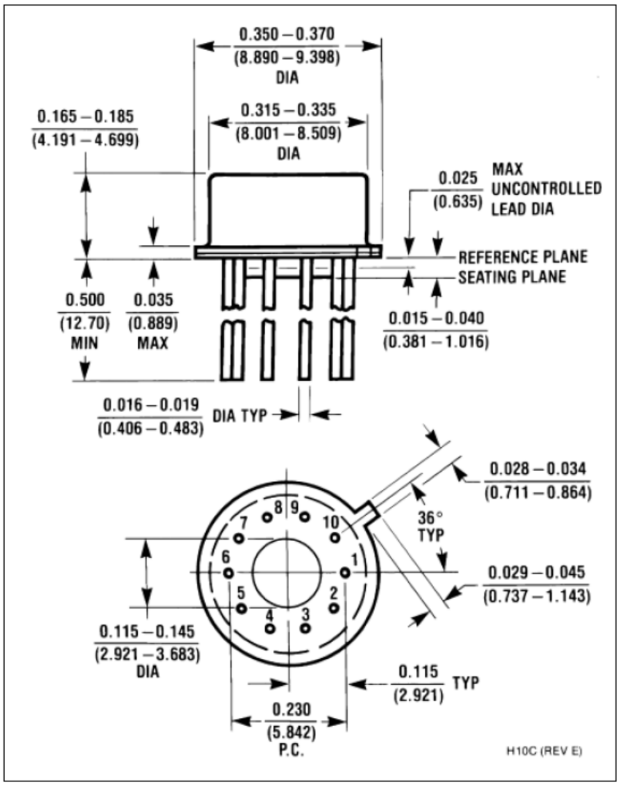
- STEP 1 :

You will have to create the KiCad design files incorporating the instrumentation stage of the gas sensor presented during "Analog electrical circuit" TPs (the components required for this are located in a small plastic bag on the Arduino shelf in the 2.15 or 2.16 room of the Physics Department!).

For the KiCAD part, you will use the TD sessions with Arnauld Biganzoli and the links to the course videos: *https://moodle.insa-toulouse.fr/course/view.php?id=494#section-3*

NB :

- 1 - The gas sensor will be placed on a TO5 box of the same type as the one of the AIME: http://fr.rs-online.com/web/p/photodiodes/7378098/



Note: 1 - Your knowledge of the gas sensor at AIME will allow you to design the best possible circuit to connect the poly-silicon heating element, the Aluminum element and the nanoparticle sensitive layer.

STEP 2: we suggest that you choose one of the following topics:

- GREEN TRACK: design the KiCad files of a shield for Arduino containing the sensor of your choice (e.g. a gas sensor with "GROVE" connection available in the instrumentation room), possibly a buzzer and a push button and which should be able to send information about the TTN network (The Thing Networks : https://www.thethingsnetwork.org/). This shield should be able to be plugged into an ARDUINO UNO card (like that of your TPs).

- BLUE TRACK: take the previous KiCad files (green track) and add a connector to insert the PCB containing the RN2483 chip, and also the possibility to connect the gas sensor to the AIME. The first GROVE sensor will allow you to calibrate the entire assembly. This shield should be able to be plugged into an ARDUINO UNO card (like that of your TPs).

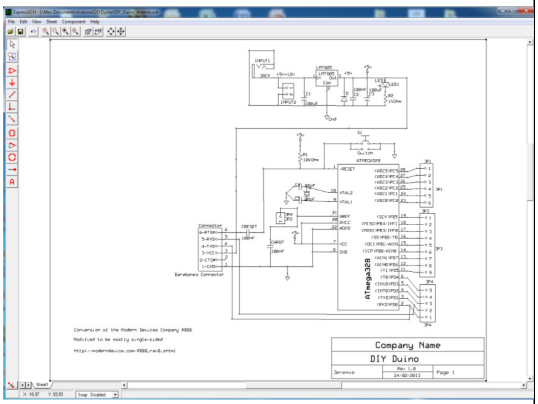
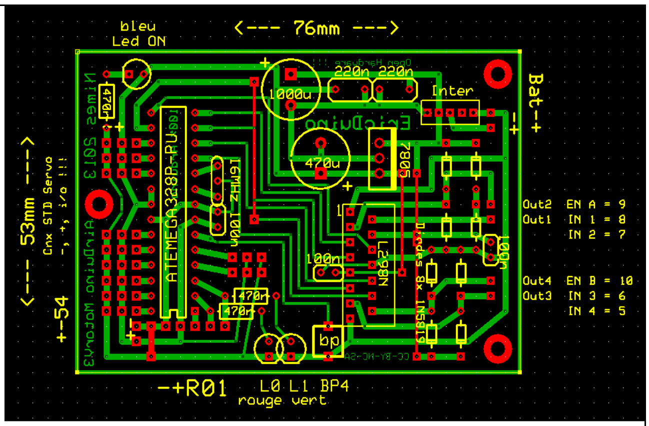
- RED TRACK: resume the previous KiCad files (blue track) and directly integrate the AIME gas sensor into them

- BLACK TRACK: take the previous KiCad files (red track) and directly integrate a "clone" of the Arduino UNO, excluding the FTDI programming chip. Optional: you can integrate OLED mentioned in paragraph TP6 of the MOODLE

- The following components are available for the transimpedance circuit (available in the TP cabinet):

TO DELIVER TO US IN THIS PART: KiCad DESIGN FILES

Example of schematic	Example of layout

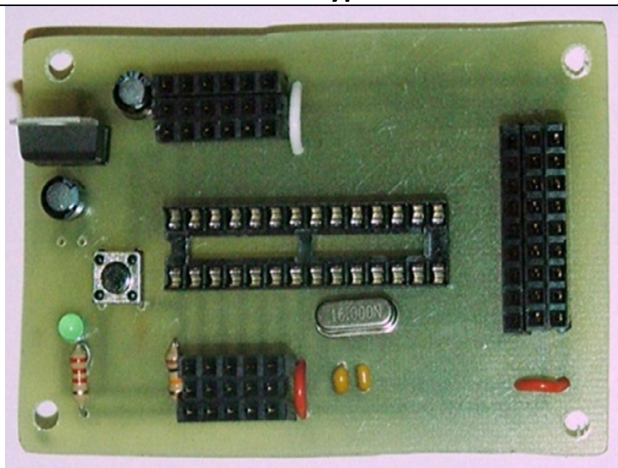
 (non contractuel)	 (non contractuel)

You will send your KiCad design files (schematic and layout) to
Arnauld.Biganzoli@insa-toulouse.fr
jeremie.grisolia@insa-toulouse.fr,
catherine.crouzet@insa-toulouse.fr;
benjamin.mestre@scalian.com

2 - IN A SECOND STEP:

We will organize a presentation session of your KiCad design files and you will select by an anonymous vote the 5 best designs that will then be drawn and welded to become the final prototype. The students of the 5 best achievements will then meet with catherine.crouzet@insa-toulouse.fr for the PCB drawing.

For the PCB, you will make an appointment again
with Catherine CROUZET to access the soldering station.

Prototype

Example of prototype (non contractuel ;-))

3 - IN A THIRD STEP:

The spirit of this UF is resolutely oriented towards Open Source Hardware. If you can develop the aspects described in the two phases described above, it is partly thanks to the contribution of the community that makes resources and software available (KiCAD, Arduino, GitHub...). **It is therefore very important that you can in return enrich the community with your work.**

We therefore ask you at the end of the module to write a document that will describe your approach and provide all the necessary resources (source code, design files...) so that others can reuse your work.

We ask you to prepare the documents to be returned according to the chosen route and to DEPOSIT them on the github of the UF Smart Devices https://github.com/orgs/MOSH-Insa-Toulouse/.

We ask you to write on the README.md file, which is located at the root of your repository (github MOSH), a complete documentation of what you have developed, keeping in mind that this documentation must allow a third party to fully understand and know how to redo your project.

All these documents MUST BE on the GitHub platform at the end of the module
! BE CAREFUL, WITHOUT THE RESOURCES AVAILABLE, YOU WILL NOT BE ABLE TO GET A SCORE !

Moreover, these documents will then be used to fill in the PORTFOLIO with skills that you will have to return to us at the end of the semester in order to validate the UF's skills.

For any request for details, do not hesitate to contact us:

Jérémie GRISOLIA : jeremie.grisolia@insa-toulouse.fr
Arnauld BIGANZOLI : Arnauld.Biganzoli@insa-toulouse.fr
Catherine CROUZET : catherine.crouzet@insa-toulouse.fr
Benjamin MESTRE : benjamin.mestre@scalian.com

We remain at your disposal for further details.