Urban AirQ / Making Sense – Pilot 1

**Technical Report Sensor Kit**

Within the execution of Urban AirQ / Making Sensor project we developed a sensor kit that could answer to the citizen request during the air quality pilot study.

This document will be structure in the following sections:

* Background
* Technical Requests and Specs of the kit
* Sensors and Boards
  + Sensors
  + Boards
* Communication
* Code
* Configuration Mode
* Production Line
* Issues
* First tests

**Background**

Many of the technical choices we made for the development of the kit are based on the ASCL project: <http://www.hindawi.com/journals/js/2016/5656245/>.

Starting from that experience and the hardware that has been used, we decided to use similar electronic parts but also to improve and integrate more functions.

From ASCL we kept:

* The main board, Arduino Uno. It’s open-hardware board for fast-prototyping applications. Nowadays it represents the simplest approach to electronic and programming on the market. We opted for Arduino Uno with the idea that anyone should be capable to reproduce and adapt our kit for his own application.
* The NO2 sensor

Some of the technical aspects that we wanted to improve are:

* 9V battery supply for portable application and 5V USB power for stationary application.
* SD card data logger shield
* transparent acrylic case

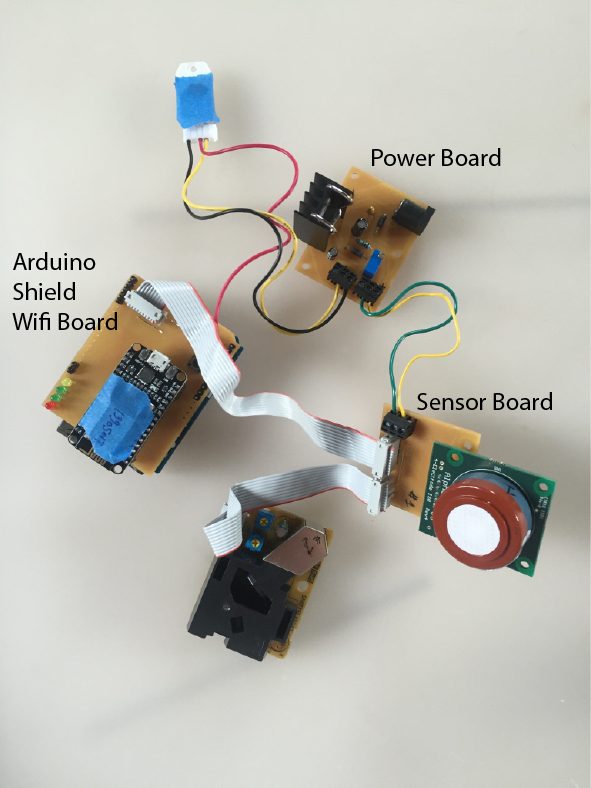
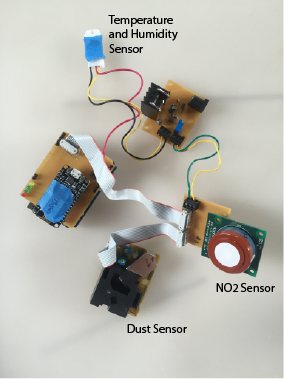
**Technical Requests and Specs**

General requests:

* Modular solution: a kit that is assembled by smaller parts (boards). These parts should be easily plugged, swapped and modified.
* Wireless data collection: the goal is to have an independent solution, independent from physical support or memory limitation while the kit is running.
* Power supply: stable and fast power management.

**Sensors and Boards**

The Kit is so composed by five boards and four sensors.

**Sensors**

- NO2 🡪 NO2-B42F and NO2-B43F, Alphasense

- Particulate Matter 🡪 PPD42NS, Shinyei

- Temperature and Humidity 🡪 DHT22, Aosong Electronics Co.

**NO2 Sensor – NO2-b42F/ NO2-b43F**

To get full sensor performance, low noise interface electronic is necessary. Alphasense offers indeed also a support circuit (ISB) that can be used to optimize the reading of low ppb levels and guarantee low noise environment. For time and resource matter, we decided to buy the sensors already soldered on their ISB (Individual Sensor Board).

Sensor Datasheet: <http://www.alphasense.com/WEB1213/wp-content/uploads/2016/07/NO2-B43F.pdf>

ISB Datasheet: <http://www.alphasense.com/WEB1213/wp-content/uploads/2016/06/ISB.pdf>

References: <http://www.alphasense.com/index.php/products/nitrogen-dioxide-2/>

Note: the pdf documents can also be found in the github repo.

**Particulate Matter Sensor - PPD42NS**

Sensor Datasheet: <http://www.seeedstudio.com/wiki/images/4/4c/Grove_-_Dust_sensor.pdf>

References: <http://takingspace.org/wp-content/uploads/ShinyeiPPD42NS_Deconstruction_TracyAllen.pdf>

Note: the pdf documents can also be found in the github repo.

**Temperature and Humidity – DHT22**

Sensor Datasheet: <https://www.sparkfun.com/datasheets/Sensors/Temperature/DHT22.pdf>

Note: the pdf documents can also be found in the github repo.

**Boards**

- Main board 🡪 Arduino Uno

- Wifi Module 🡪 ESP8266 development kit, NodeMCU 1.0

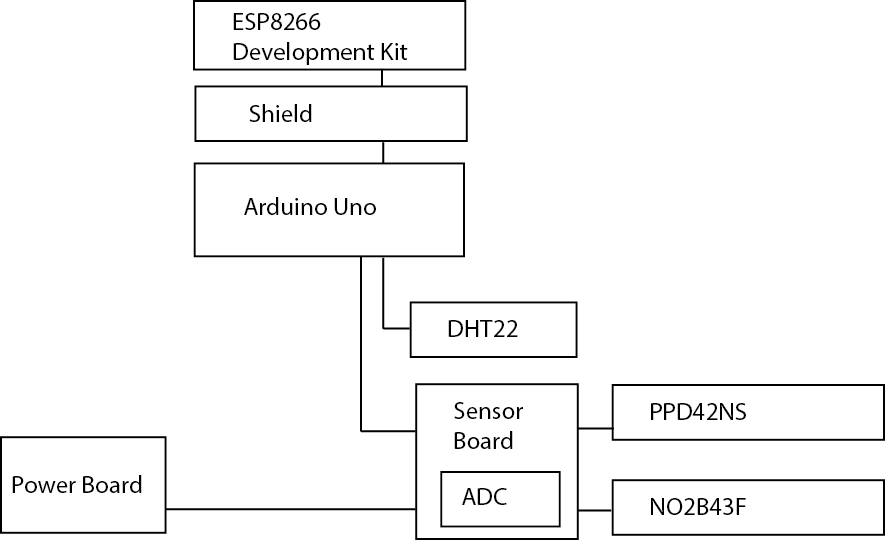
- Shield -> designed and produced in Fablab Amsterdam

- Sensor Board -> designed and produced in Fablab Amsterdam

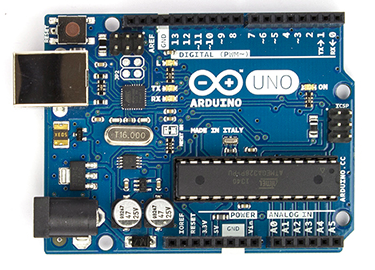
- Power Board -> designed and produced in Fablab Amsterdam

Note: original design files can be found in the repo.

The image below shows the general block diagram of the kit.

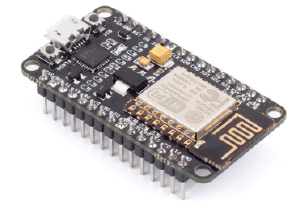


**Main board**



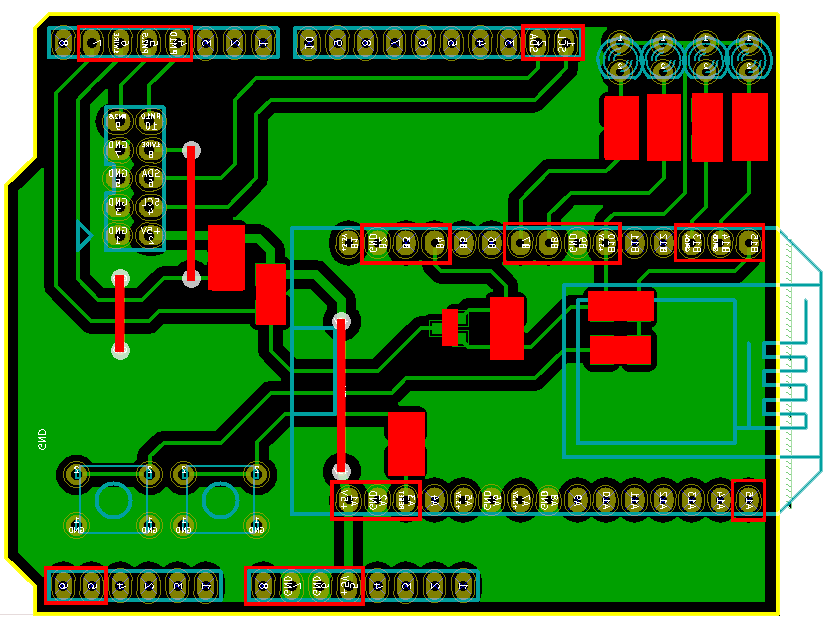
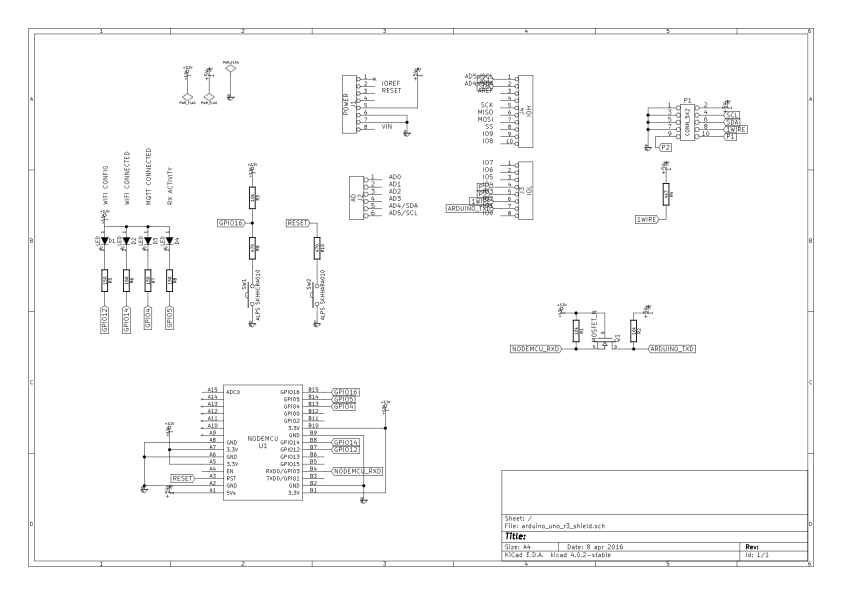
The main board manages the reading of the sensors and collects/sends the data to the Wifiboard.

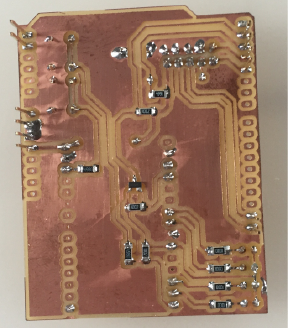
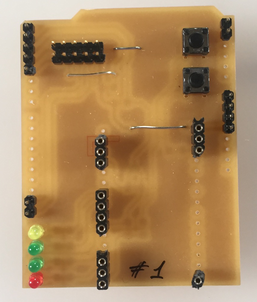
**Wifi module**



The wifi module is a NodeMCU development kit 1.0. The advantage to use the whole development kit instead of the single wifi module, is the possibility to program the ESP8266 chip without the need of extra hardware, as an FTDI cable or chip. To flash this module you only need a micro usb cable and of course the right setup in the software. In our application the module has the function to receive the data from the main board, prepare the payload for the server and send it every minute.

**Shield**

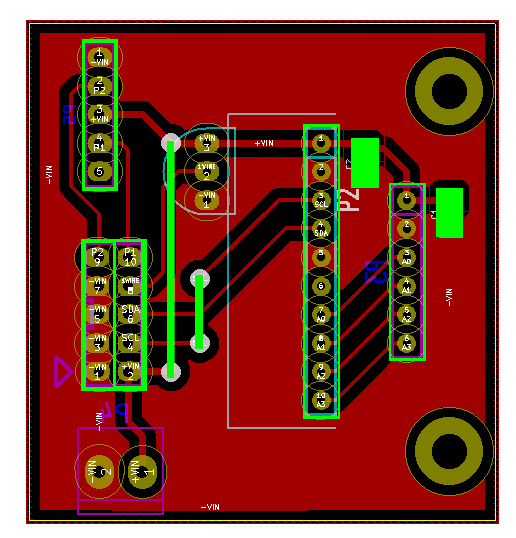
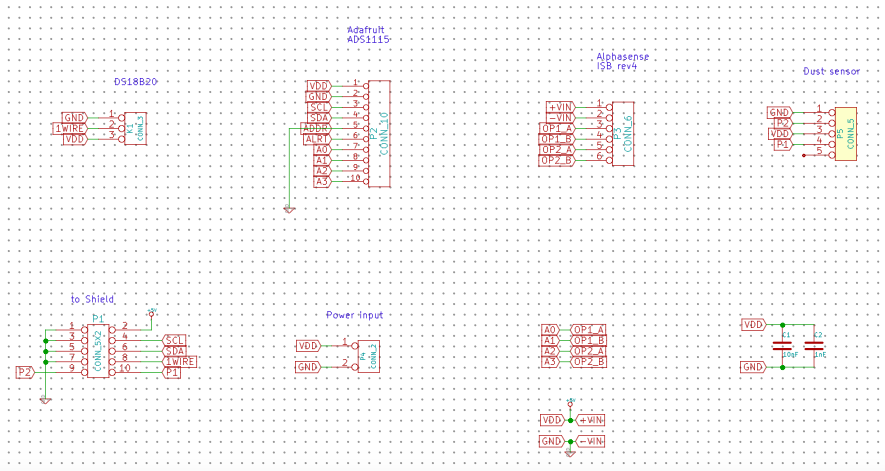


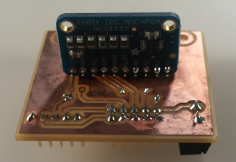
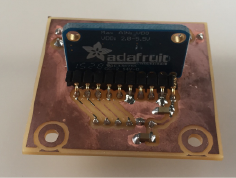
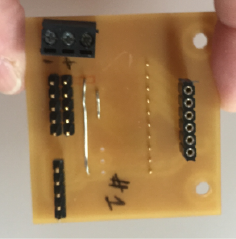


The shield has several functions:

* It is the interface between Arduino UNO and the ESP8266 module. On the shield there is indeed the level shifter that allows the communication between the 5V and 3.3V domains, respectively of the main board and the esp8266.
* It helps the functional debugging. There are indeed four led that helps to understand what is the operational mode and if there are some issues with the communication.
* LED 1: yellow led. It indicates the configuration mode.
* LED 2: green led. It indicates if the kit is connected to the wifi.
* LED 3: green light. It indicate if the kit can reach the MQTT server.
* LED 4: red light. It blinks when there a communication signal from the main board to the ESP8266.
* It has two switches:
* SW 1: it’s used to go in configuration mode.
* Sw 2: reset button
* It’s the physical support of the power lines for the main board and the esp8622

**Sensor Board and ADC**

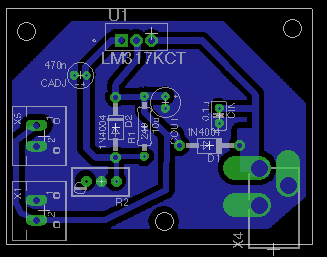
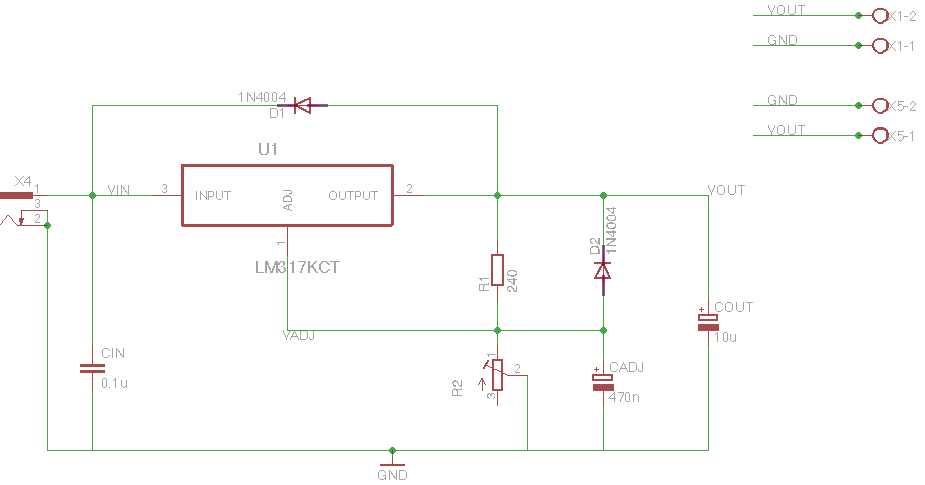


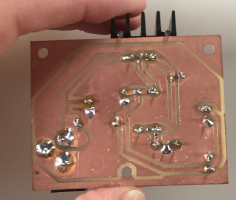
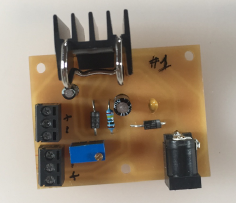


The sensor board is used to:

* to bring the power (5V) from the regulator to the main board.
* To host the ADC (Analog to Digital Converter) that is necessary to read the output of the NO2 sensor. See Code-Sensor section. The ADC is an ADS1115 4 channel (Adafruit Breakout board).
* To connect the NO2 sensor to the ADC.
* To connect the Dust Sensor to the main board.

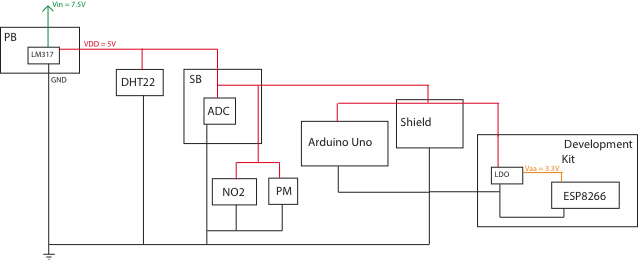
**Power Board and Power Management**





The Sensor Kit works at 5V that is generated on the power board by the LM317, adjustable three-terminal positive-voltage regulator. The output voltage is adjusted by the use of the potentiometer.

Power Management block diagram



The kit is powered at 7.5V with a universal wall adapter. The power board generates and regulates the 5V that supplies the kit through the sensor board. The dht22 is directly connected to the power board because the original design didn’t include the temperature sensor. It has been a late request and the time didn’t allow the its embedded implementation.

**Communication Protocols**

The image below shows the communication connections and protocols used between the different boards and devices.

Starting from the sensors, the NO2 sensor is read by ADC (ADS1115) that communicates with the Arduino Uno through I2C protocol. The Dust sensor is simply connected to two digital pins of the main board and it doesn’t require standards to be used. The DHT22 includes both the temperature and humidity sensors and it can be used through single-bus support.

The Arduino Uno transmits the data to the ESP8266 using the integrated Serial Ports of the Arduino microcontroller. In this application the communication is one direction so only one wire is used (TX on the main board and TX on the development kit). Eventually the data are sent on air based on MQTT protocol.

Note: for library and code, see the Code section.