3D-Printed Module for Air Flow Control of PPD42 Particle Sensor

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Introduction & Motivation

Affordable particle monitoring instruments based on low-cost sensors can increase existing measurements density & coverage (Holstius 2014).

Low-cost optical particle sensor, model Shinyei PPD42NS (Fig. 3) has been already employed for several different air pollution monitoring devices:

- Air quality monitoring device described by Chris Nafis (Nafis, 2012).
- Prototype of fine particulate matter Portable and Affordable Nephelometric Data Aquisition (PANDA) system (Holstius, 2014).
- Portable University of Washington Particle (PUWP) monitor (Seto, 2014).
- DustDuino (Schroyer, 2013) project.

Examples of promising particulate matter ($PM_{2.5}$) measurements using Shinyei PPD42NS sensor in California (Holstius, 2014b) and in Xi'an, China (Gao 2015) can be found in Fig 1. and Fig 2.

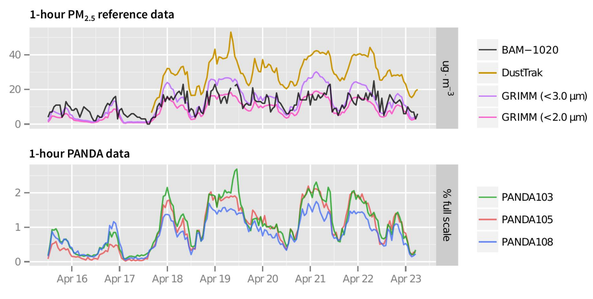

Fig 1. Hourly data collected at the West Oakland site. Top: $PM_{2.5}$ measurements by BAM-1020, DustTrak & GRIMM. Bottom: PPD42NS sensors (Holstius, 2014b).

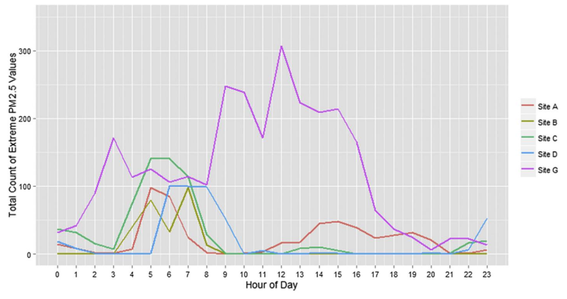

Fig 2. Daily data collected using PPD42NS sensors in city Xi'an (China) at different sites (Gao 2015).

Computer-aided design

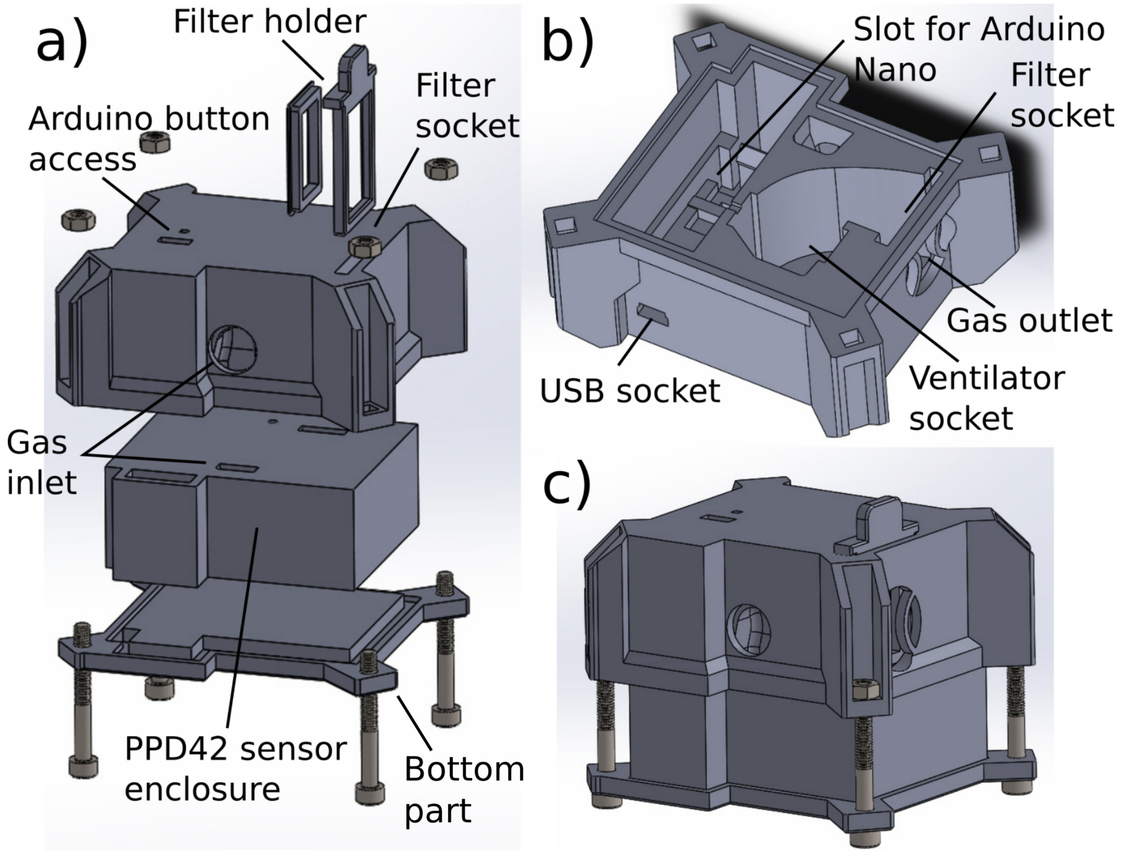

Fig 4. 3D visualization of modular solution for Shinyei PPD42NS sensor: a) System assembly with all components, b) upper section for Arduino Nano, ventilator and filter, c) all components assembled together.

Sensor PPD42NS

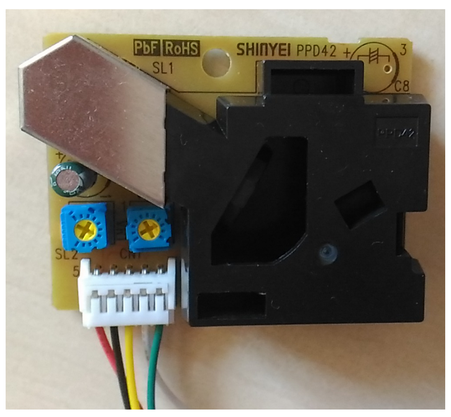

Fig 3. Shinyei PPD42NS sensor.

- Aerosol is drawn by means of a convection flow by heat of a small 0.25 W resistor through the sensing volume.
- Airflow is sensitive to orientation with respect to gravity, flow rate is not known and hard to be quantified. Moreover, gas flow in sensing volume can be influenced by external air flow conditions (e.g. wind).
- Sensing volume can be also possibly influenced by external light.

Aim

Improve reliability and reproducibility of measurements using PPD42NS sensor using freely available modular 3D printed solution which includes enclosure box for sensor together with venting exhaust fan system for forced air flow through sensor.

Results

Modular 3D printed solution for PPD42NS sensor includes an enclosure box together with a venting exhaust system with a fan for forced air flow through the sensor (the fan is powered using Arduino 5 V voltage, the heating resistor for convective flow can be disconnected), a slot for Arduino Nano & an output filter.

Data for 3D print freely available at http://www.nanometrologie.cz/particles.

Schematics for connection of sensor to Arduino & operating software can be found e.g. on http://wiki.seeed.cc/Grove-Dust_Sensor/ (caution: colors of sensor cables vary, therefore always connect the sensor to Arduino according to pin numbers).

Alternative software is under development and is available at http://www.nanometrologie.cz/particles.

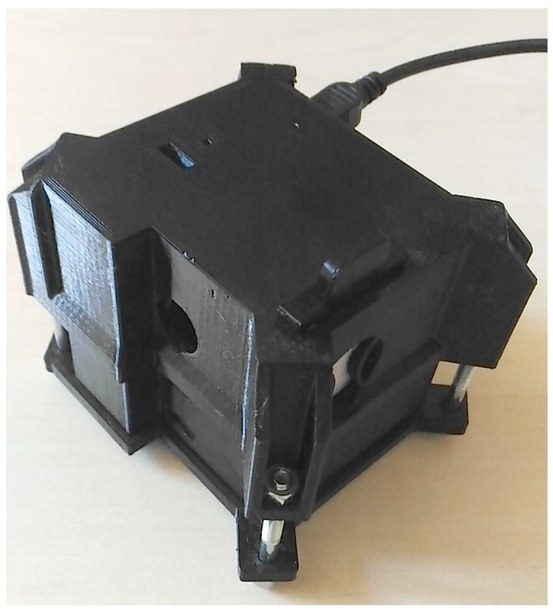

Fig 5. 3D printed solution for Shinyei PPD42NS sensor. Sensor is embedded in lower section, upper section contains Arduino Nano, ventilator and filter.

Conclusion & Future outlook

Operation of sensor embedded in presented system has several advantages due to stable forced gas flow, which can be also determined. This can help to better interpret and quantify results obtained by the sensor. Further components can be easily designed, created using additive manufacturing and added to the system (e.g. casing for outdoor operation, isokinetic probe, module for batteries).

Performance of the particle counting system was tested for several days of operation using Arduino microcontroller with standard (Schroyer, 2013) and modified code. The detailed analysis of PPD42NS sensor performance is out of scope of this contribution, however preliminary results indicate rather low counting efficiency.

There are several subjects that should be investigated to better understand the measurements performed using PD42NS sensor such as estimation of counting efficiency for different particle sizes, determination of gas flow rate through sensor, comparison of results obtained with presented solution with alone-standing sensor.

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