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Sensing platform development for air quality measurements and analysis

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Abstract

- **Air quality degradation is the result of combining different substances which consist of solid particles in the air.**
- **Such particles can be: ozone, car emissions, different chemicals from factories, etc. Some of these substances are hazardous for human health.**
- **After defining the air pollution sources, different actions can be taken to decrease air pollution levels.**
- **Therefore, it is a paramount need to implement a sensing platform for monitoring the air quality.**
- **The aim of this paper was to implement an integrated sensing platform for real time air quality measurements in Capital City of Kosovo, Prishtina.**
- **The main components of this platform are Arduino Board (Arduino Uno) and Air Dust Sensor Shinyei PPD42.**

Introduction

- According to World Health Organization (WHO), every year there are about 3 million of people dying from air pollution; 1.5 million of these deaths are attributed to the air pollution in closed areas.
- In 2012, approximately 6.5 million deaths were from indoor and outdoor air pollution.
- This number is around 11.6% of all deaths. During the year, there are more deaths from air pollution than from car accidents.

Introduction

- Measurements and monitoring of the air quality are essential for analyzing heterogeneous environments with different emission sources, like in urban areas [1].
- Monitoring of PM10(Particulate Matter) and PM2.5 needs to be improved in Kosovo, in order to evaluate the exposure of the population and to assist responsible authorities for improving air quality.
- It is clear that decreasing levels of air pollution will result in health benefits for the population.

Introduction

- In this paper, we have developed and implemented a sensing platform in the laboratory, which measures air quality, it can be used for monitoring and can provide data for analysis.
- This platform is based mainly on Arduino Technology.
- First, we explained the electromechanical sensors as an equipment which will help us develop this project, PPD42 sensor and its characteristics and as well the interconnection scheme.
- Next, we calculated the concentration of PM10. On the end we will present and comment the final results for some of the measurements realized with this sensing platform.

MAIN CHARACTERISTICS OF ELECTROCHEMICAL SENSORS

- Electrochemical sensors are the most rapidly growing types of chemical sensors.
- Chemical sensors are devices used for providing information regarding environment.
- They consist of a transducer and chemically selective layer.
- According to the property, they can be classified as: electrical sensors, optical, thermal, etc.
- In comparison to electrical and optical sensors, electrochemical sensors are simpler and have lower cost [5-10].

MAIN CHARACTERISTICS OF ELECTROCHEMICAL SENSORS

- For this paper/project, we have used SHINEY PPD42 sensor, which is used for air quality calculation, mainly for PM10 concentration in dust bubbles, but it also supports measurements of PM 2.5 as well. PPD sensor functioning is shown in the Figure 1.

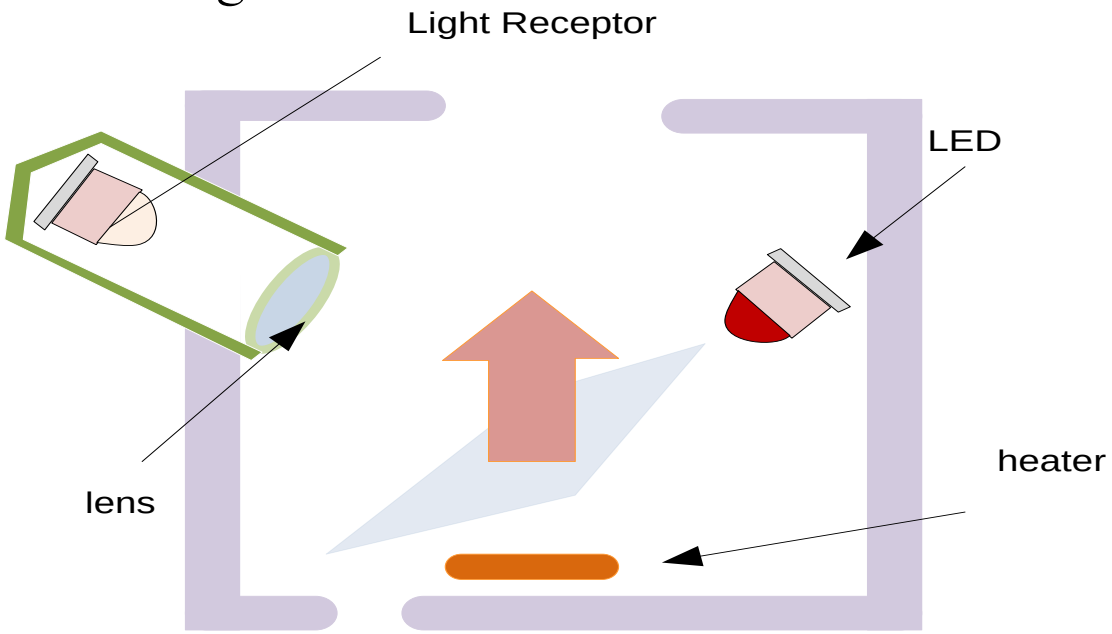


Figure 1. PPD sensor

PROJECT ENVIRONMENT AND INTERCONNECTION SCHEME

- In this section, we gave a special attention to the project environment and the interconnection scheme of referencing elements. The interconnection scheme, for some of the connected elements, can be seen in Figure 2.

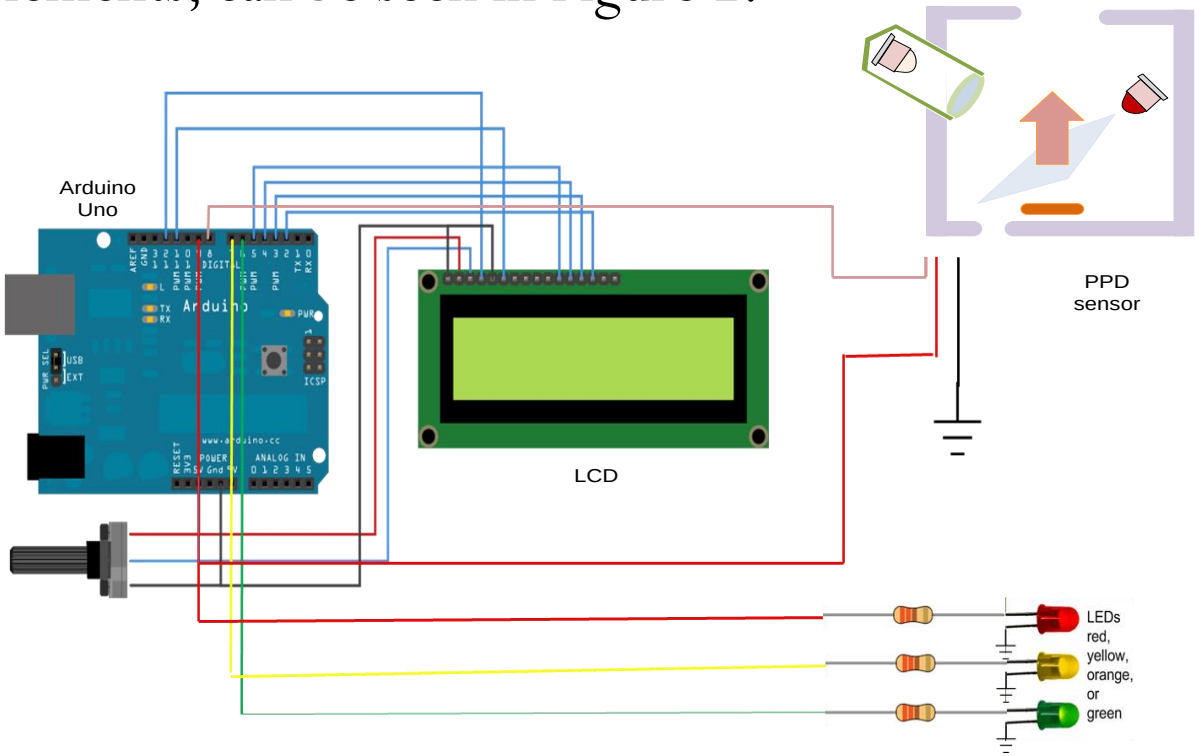


Figure 2. Interconnection scheme

AIR QUALITY INDEX CALCULATION

- It is well known that Air Quality Index (AQI) is very important in order to identify the air quality in different environments.
- There are different systems which can calculate AQI index.
- These systems should be capable of monitoring different air pollutants in real time, informing the people regarding current air quality status and sending the information to a centralized server [2], which can then generate statistics and reporting.

AIR QUALITY INDEX CALCULATION

- In this section, we have developed one algorithm called "Algorithm for index calculation".
- The aim of this algorithm is to calculate the air quality, based on the values taken from AQI(Air Quality Index) standards [7], and to show results in basic format in the LCD and (but not limited to) show relevant color or color combination of the LED Lights .
- This algorithm shows the basic steps which are implemented in this platform

ALGORITHM FOR AIR INDEX CALCULATION

Step 1: Equipment Startup

LED Startup for checking
PPD42 Sensor WarmupLCD Startup for Checking

Step 2: Air Quality measurement using PPD42 Sensor Logic

Step 3: Generating values for PM10 concentration Ratio, LOW Pulse Occupancy based formula

concentration = 1.1*pow(ratio,3)-3.8*pow(ratio,2)+520*ratio+0.62;

ratio = LOW_pulse_occupancy/(sampletime_ms*10.0);

Step 4: Comparing results of concentration with the logic and executing commands for LED lights and LCD Print Messages

if (concentration<=50)
Print this result in LCD: I Paster
else if (concentration<=150 && concentration>=51)
Print this result in LCD: Mesatare
else if (concentration>=151 && concentration<=350)
Print this result in LCD: Pa-Paster
else if (concentration>=351&& concentration<=420)
Print this result in LCD : I-Pa-Shendetshem
else if (concentration>=421)
Print this result in LCD : HAZARD

Step 5: Repeat process every 60 seconds

MEASUREMENT RESULTS AND ANALYSIS

- The best way of describing and analyzing PM is by considering the concentration of the particles with diameter of less than 10 μm (PM10) and with diameter of less than 2.5μm (PM2.5).
- In most of the European countries, PM2.5 constitutes 50-70% of PM10.
- PM is a combination of the physical and chemical characteristics.
- Chemical ingredients of PM include sulfate, nitrates, ammonium, ions of sodium, potassium, calcium, magnesium and chloride, organic and elemental carbon, crustal material, particle-bound water, metals (including cadmium, copper, nickel, vanadium and zinc) and polycyclic aromatic hydrocarbons (PAH) [11-12].

MEASUREMENT RESULTS AND ANALYSIS

- These results are better shown graphically in Figures 3 and 4,

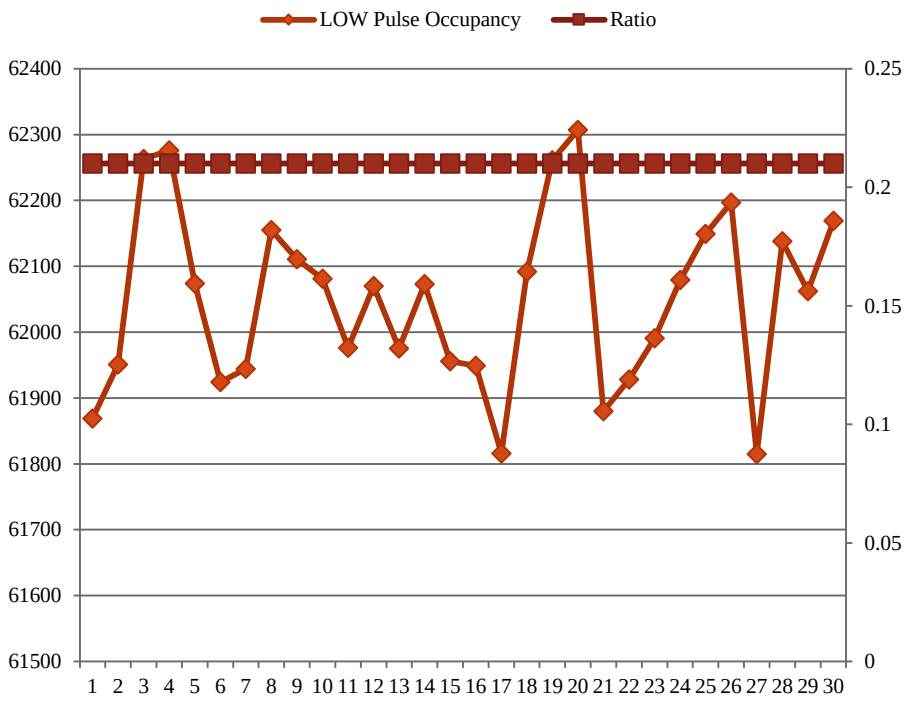


Figure 3. Low Pulse occupancy vs. Ratio

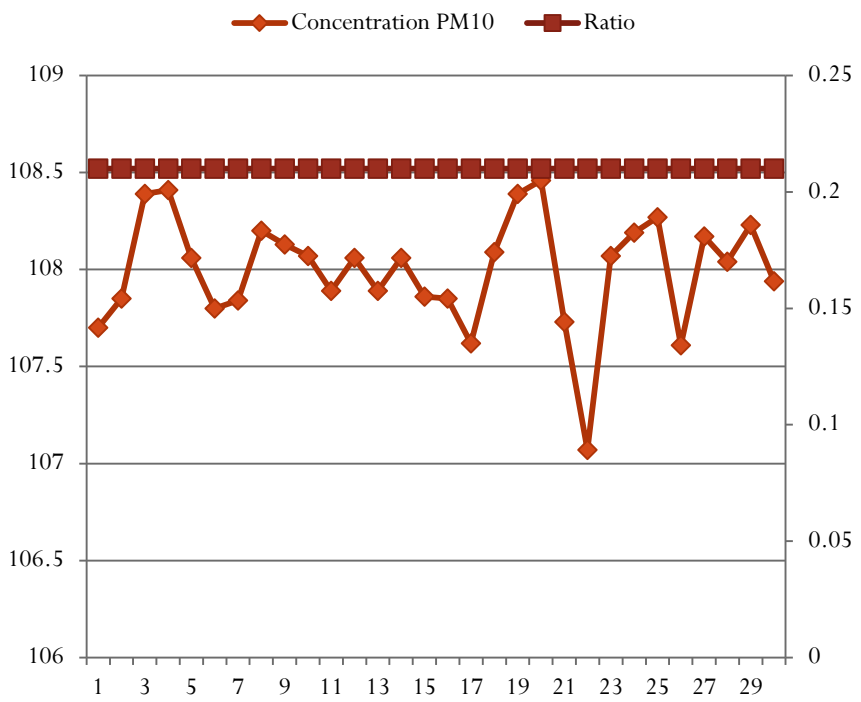


Figure 4. PM10 Concentration versus ratio.

MEASUREMENT RESULTS AND ANALYSIS

- As we have mentioned in the developed algorithm, the ratio is calculated as the report of low pulse occupancy per samples in ms.
- In our measurements we gained the constant values for ratio, for every measurement that we did.



Figure 5. Results displayed after measurements in LCD Monitor

CONCLUSIONS

- Lately, air quality has become a real concern in overall Kosovo, but also in countries with large number of factories, such as China.
- For Kosovo, this concern was initially triggered thanks to the US Embassy in Prishtina, by generating in real time the reports regarding the hazardous air quality
- We think that for Kosovo, there is an urgent need to have strict air quality standards, such as the limitation for emissions from different sources, especially from traffic cars, using Coal as the main option for heating during the winter time.
- Therefore, it is very important to continuously monitor air quality in order to be aware the responsible authorities and try to take concrete steps for reducing air pollution.

CONCLUSIONS

- This paper proves that implementing an integrated sensing platform for air quality measurements can be achieved with a Low Cost.
- With low cost investment, there can be sufficient data inputs to raise the attention that one of the main cause of global warming and as well the key factor of the increased number of diseases, is the Air Quality, which needs to be controlled.
- This sensing platform can be used as a very sufficient information source towards the municipalities, in order to direct the investments into “Green” Society and building parks and also taking control over the pollution sources.
- It can be a very small part of contribution, on helping cities reduce the air pollution and also it can be used as a contribution against the Global Warming.

THANK YOU!

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