LED-BASED ARCHITECTURE FOR AIR EMISSION MONITORING

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Abstract: We present an architecture of controlling a proposed spectrometer system for detecting pollution in water and gas. The system is based on LED sensors using a Michelson interferometer and stepper –motor for moving split mirrors. The system is designed so that changes in LED light intensity could allow to detect a wide spectrum of polluted substances. The architecture uses a special duty-cycle to reduce the uncertainty of pollution detection. The electronic board of the system has been constructed and tested with encouraging results thanks to the use of a PMT (photomultiplier tube).

Keywords: Air pollution, Light Emitting Diode, Pollution detection, eparate ecological collection, waste management, weight sensors, cost minimization

1. INTRODUCTION

Nowadays an increasing use of energy, besides continuous search of alternate sources to fossils, acquires a vital importance because of necessity to increase car efficiency. There is also a need of decreasing gas emissions that are particularly lethal for earth and life [1]. This problem is a matter of concerns in huge cities where traffic jams contribute to raising of hazardous and harmful emissions. Therefore, the development of hybrid car, with high efficiency and reduced environmental impact, based on fossil energy uses and optimized by exploiting electronic know-how, plays a crucial role [2]. Urban air pollution is therefore one of the most important environmental issues that may be considered due to its direct effect on human health. It mainly results from anthropogenic (human) activities and has diverse causes and sources. "Stationary sources," such as factories, power plants, and smelters; "area sources," which are smaller sources such as dry cleaners and degreasing operations; "mobile sources," such as cars, buses, planes, trucks, and trains; and "natural sources," such as windblown [3] dust and wildfires, all contribute to air pollution. Due to the trans-boundary nature of airborne pollutants, it is difficult for any single organization to take responsibility for overall emission levels [1]. Thus, the control of air pollution is entirely legislation driven [4]. As such the passing of new legislation may only be effective if the specified compounds can be monitored accurately [5]. The primary airborne pollutants covered by European legislation are: SO_2, NO_x (NO/NO_2), benzene, Ozone, CO/CO_2, and particulate matter (PM10/PM2.5) [6]. Concerns with emissions of volatile organic compounds (VOC) from waste industrial facilities are increasing, but monitoring waste facilities is complex for both economical, computational and practical reasons [7]. Data from industrial processes are sparse, it is frequently necessary, therefore, to make estimates of emission factors on the basis of material balances, yields, or process similarities. Conventional emission estimations focus on statistical treatment and standardization of emission sources with consequent collection data strategies on measuring concentrations.

Beyong direct measurements, prediction of validation of pollution is a specific area of air monitoing where different algorithms have been developing to assure a complete mechanism of knowledge. Gaussian, lagrangian, Poissonian, etc are types of prediction modeling used in diverse field among which we find geostatistic ones [8]-[11].

2. LED SOURCES AND SENSORS

Bring system or separate ecological collection is a method (and a location) where people and users bring segregated materials to be put in separate containers or A brief and salient literature on specific LED-based applications is described in the present paragraph. By far, the majority of LED applications encompass absorbance measurements in flow-through cells. Hauser and Chiang are among the most active in the use of LEDs as spectroscopic sources and were the first to report the use of a blue LED as a spectroscopic source as these devices first became available [12]. Early blue LEDs were not particularly bright and efforts were especially made to adapt or even develop chemistry such that yellow to red LEDs, traditionally, the brighter emitters, could be used [13]. Benson and Worsfold leads another group active in the use of LEDs and has described high reliability flow-based

measurement systems for dissolved Fe and monomeric Al [14]. LED-based detectors are smaller, less expensive, and provide performance as good as any commercial alternative. Fig.1 illustrates an example of LED device and typical heterojunction of carriers transportation os depicted in fig.2.
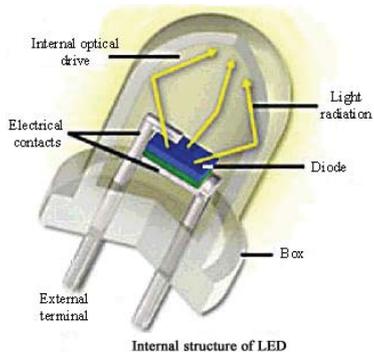

Figure 1. LED device.

The stability and reliability of LEDs have led to field and process analytical chemistry applications. Worsfold and co-workers have used the above ammonia measurement strategy for process monitoring as well [15] and Hauser et al. have reported on a process monitor for nickel in ammoniacal media that uses a near infrared (NIR) LED as a source. Tan et al. [16] were among the first to describe a multi-wavelength spectrometer containing multiple LEDs and phototransistors controlled by an 8031 microprocessor.
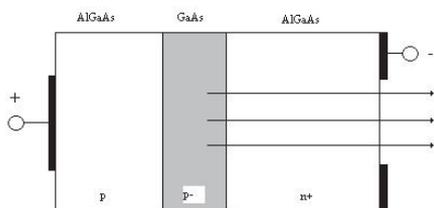

Figure 2. Heterojunction structure

Like all electronic devices LED also displays a frequency response described in Eq.(1) and depicted in fig. 3.

$$r(\omega) = \frac{|L_e(\omega)|^2}{D_e \tau} = \frac{1}{\sqrt{1 + \omega^2 \tau^2}} \qquad (1)$$
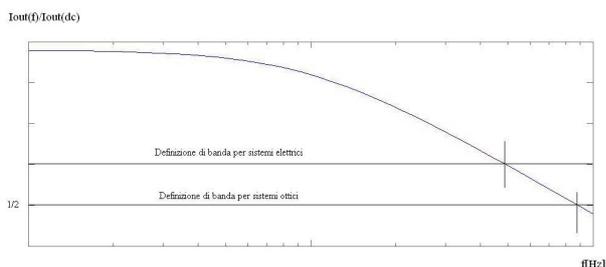

Figure 3. Frequency response

3. PROPOSED ARCHIECTURE AND CASE

The proposed architecture is based on the scheme of fig.4 where the following units are illustrated: radiation source based on LED device, a specimen block, a selector of wavelength for changing frequency according to the sample under test, a photoelectric detector and a unit of displaying based on labview interface.

Figure 4. Eterojunction structure

The preliminary overall view of the instrumentation under construction is illustrated in fig. 5. That is the final version of the instrumentation dedicated for spectroscopic measurements. The presented architecture is a part of this instrumentation.
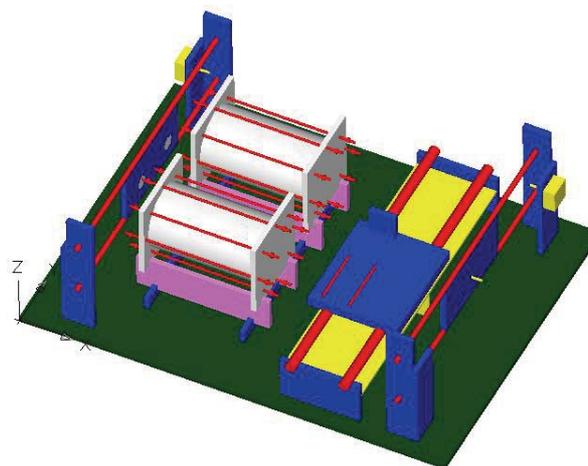

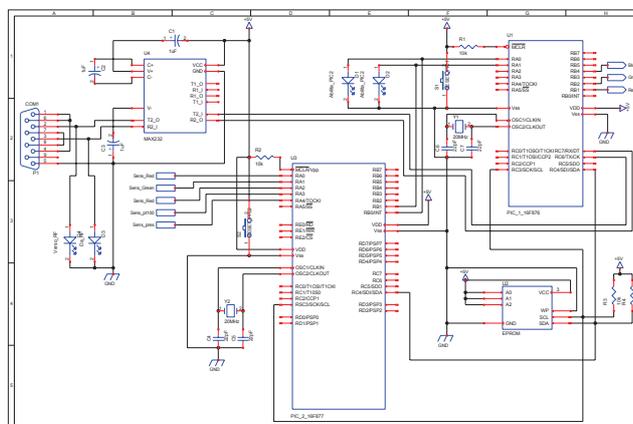Figure 5. 3D representation of proposed instrumentation

Figure 6. Control unit based on PWM .

The control of the architecture of figure 4 is based on PWM (Pulse Wave Modulation) technique as shown in

the designed (fig.6) and constructed board (fig.7). However the detector used (fig. 8) in order to reveal the LED radiation captured by the system a RGB of S7505-01 that produces noise that has been removed thanks to a dedicated conditioning circuit as included in fig. 8.
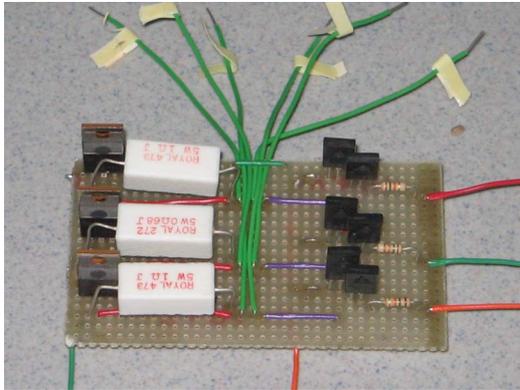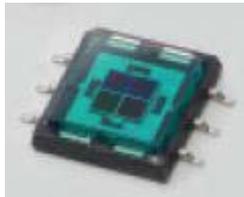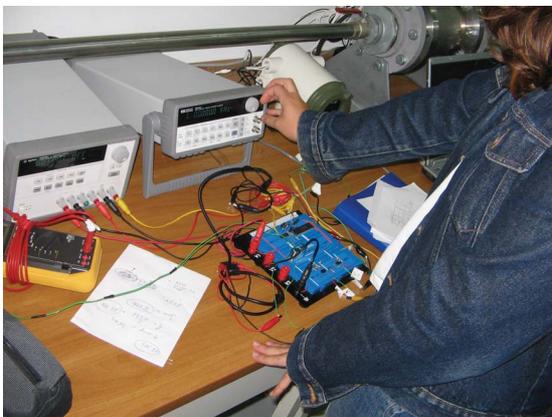

Figure 7. PWM board

Figure 8. RGB sensor

Figure 9. Construction and testing session

4. RESULTS AND FINAL COMMENTS

The main outcomes of the architecture testing is the output voltage at PIC microcontroller used for the architecture by varying the duty-cycle (fig. 10). We have two examples of this behaviour in fig. 11 and in fig.12. LEDs are increasingly assuming a significant role in chemical and physical analysis [17], in particular, in gas sensing systems. For the time being, the foreseeable impact of LED-based devices for

dedicated research instrumentation [18] [19] is very significant. LEDs provide an advantage that no continuum source, choppers or combination thereof can match. Indeed, amplitude stability of pulsed LEDs tends to be better than that of corresponding laser diodes. Concerning the implemented chamber, the choice fell on a single step-based resonant cell, even if, in some features, this kind of cell has the advantage of having a volume greater than of a non-resonant one, and this limits its use for small and compact systems for on-site monitoring of gaseous species.
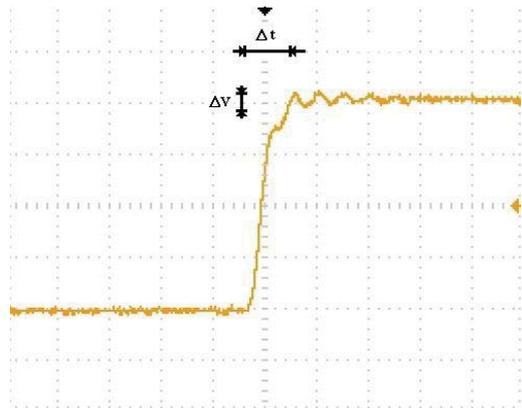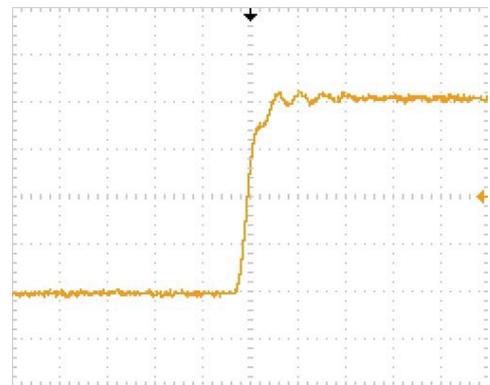

Figure 10. PIC output signal indications
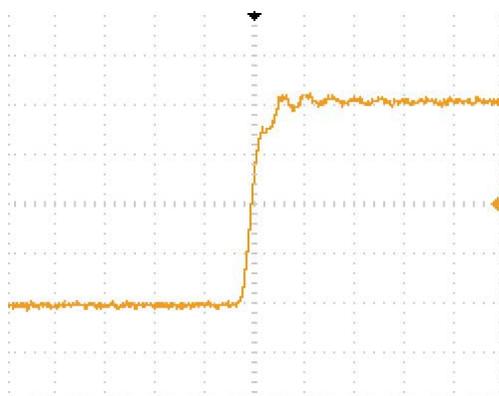

Figure 11. PIC output with 50% of duty-cyle

Figure 12. PIC output with 70% of duty-cyle

But prediction as recalled above is a very important issue for air monitoring [20]. Automatic weighting of

pollutant sample by means of nanomaterials could be a further improvement [21].

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