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Portable Electronic Nose for Emission Testing: CO, CO_2 and HC

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Abstract: Electronic nose applications in environmental monitoring are nowadays of great interest, because of the instruments' proven capability of recognizing and discriminating between a variety of different gases and odours using just a small number of sensors. Such applications in the environmental field include analysis of parameters relating to environmental quality, process control, and verification of efficiency of odour control systems. This article reviews the findings of recent scientific studies in this field, with particular focus on the abovementioned applications. In general, these studies prove that electronic noses are mostly suitable for the different applications reported, especially if the instruments are specifically developed and fine-tuned. As a general rule, literature studies also discuss the critical aspects connected with the different possible uses, as well as research regarding the development of effective solutions. However, currently the main limit to the diffusion of electronic noses as environmental monitoring tools is their complexity and the lack of specific regulation for their standardization, as their use entails a large number of degrees of freedom, regarding for instance the training and the data processing procedures. Emissions of many air pollutants have been shown to have a variety of negative effects on public health and the natural environment. With the ever increasing population and the need for automobiles for transportation, the number of vehicles have increased considerably which has lead to increase in the emission of air pollutants such a CO, CO2, Hydrocarbons, SO2, etc., which may cause grievous problems to living beings and environment. One solution to this problem is frequent monitoring of the gases in the environment. In India, the present emission monitoring system is available only at emission testing centres located either in petrol bunks or few other places. The model we have designed can be handed over to the traffic police for continuous and instant monitoring of emission levels of vehicles. The present standard device is not portable and involves wired connections unlike our design which is portable, rechargeable and wireless. These features make our design easier to use than the traditional device. Also, our new model is comparatively cheaper than the existing device with the same level of accuracy.

Keywords: Electronic nose, CO, CO2, Hydrocarbons, SO2, Emission testing, continuous and instant monitoring of emission levels of vehicles, only at emission testing centres, comparatively cheaper, COPD and environmental quality.

I. INTRODUCTION

Probably the most important area of environmental application for electronic noses is air quality monitoring. In fact, the need for an instrument capable of evaluating air pollution quickly, economically and continuously, has led many researchers to study how develop specific electronic noses for that specific purpose. While on the one hand, air quality has already been related to the presence/absence of specific chemical pollutants, in recent times, this has been broadened to include odour annoyance as a form of air pollution. Therefore, aside from developing electronic noses to detect specific pollutants, many studies w carried out on the use of electronic noses applied for odour detection, classification and/or quantification. This is particularly interesting because while other better established and solid analytical techniques can be used to detect specific compounds, electronic noses are currently the only method capable of quantifying and classifying odours in real time. In fact, many studies discuss the fact that chemical analysis is not always suited to quantifying odours because of the interactions that can take place between the different molecules in an odorous mixture, in addition to the difficulty of detecting the presence of molecules responsible for olfactory perceptions, which are sometimes present at very low (ppb) concentrations [1]. As far as odour quantification is concerned, dynamic olfactometry is the official method used to determine the odour concentrations of gas samples [2]. This technique allows one to measure the odour concentration of emissions, but it does not provide any information regarding the type of odour. Furthermore, dynamic olfactometry is not suitable for measuring the presence of odours at the receptors, or for evaluating odour exposure, whereby the odours are characterized by very low odour concentrations, often comparable to those typical of ambient air [3]. Additionally, this method cannot be used for continuous monitoring purposes because of its intrinsic discontinuity and the high costs associated with sampling and analysis. As a consequence, electronic noses are currently considered as the only possible tool for continuously analysing air in order to detect the presence of odours and defining the quality and/or concentration of said odours.

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II. MOTIVATION

The present emission monitoring system is almost outdated. It is only available at emission testing centres, is not portable, expensive, involves using long wires and also requires paperwork. So we have developed a device named electronic nose which is of low cost, has almost the same accuracy, portable, wireless, instant monitoring device and can be used anywhere, anytime by individuals who intend to monitor the emission levels. If this device is used to monitor the emission levels by traffic police on road, rigorous monitoring of emission levels can be achieved and required actions can be taken against the defaulters.

III. WORKING PRINCIPLE

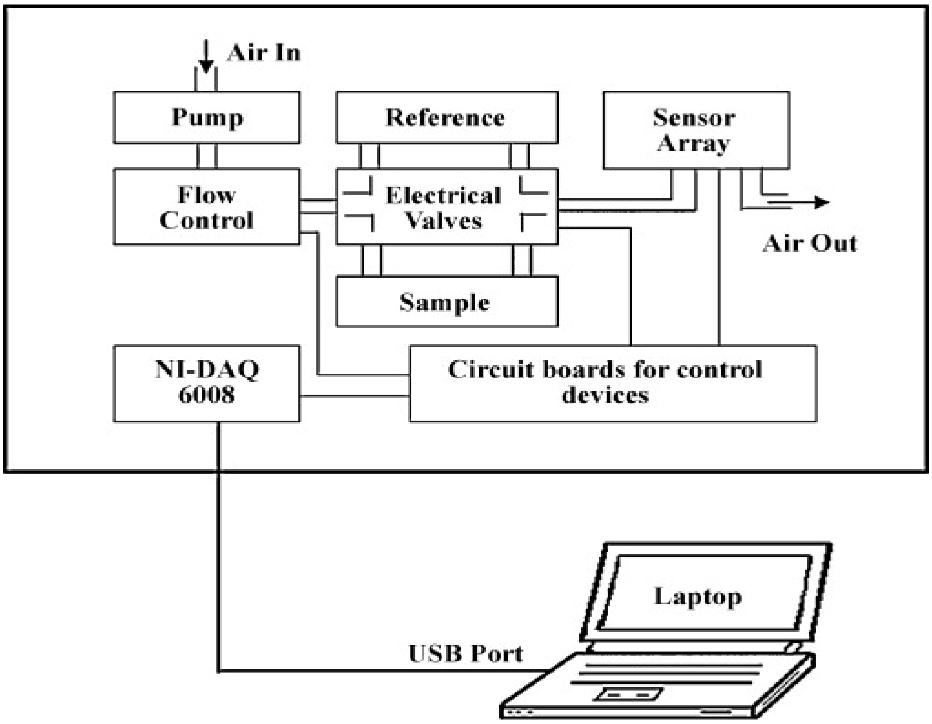

Figure 1 show the working principle of electronic nose.

The electronic nose was developed in order to mimic human olfaction whose functions are non separate mechanism, i.e. the smell or flavour is perceived as a global finger print. Essentially the instrument consists of sensor array, pattern reorganization modules, and headspace sampling, to generate signal pattern that are used for characterizing smells. The electronic nose consists of three major parts which are detecting system, computing system, sample delivery system.

The sample delivery system: The sample delivery system enables the generation of headspace of sample or a volatile compound which is a fraction analysed. The system then sends this head space into the detection system of the electronic nose.

The detection system: The detection system which consists of a group of sensors is the reactive part of the instrument. When in contact with volatile compounds at that time the sensors react causing changes in electrical characteristics.

The Computing system: In most electronic noses each sensor is sensitive to all molecules in their specific way. However, in bioelectric noses the receptor proteins which respond to specific smell molecules are used. Most of electronic noses use sensor arrays that react to volatile compounds. Whenever the sensors sense any smell, a specific response is recorded that signal is transmitted into the digital value.

IV. CIRCUIT DIAGRAM

Figure 2 shows the circuit connections of a general MQ sensor. This connection is the same for all three sensors. The sensed data is now transmitted to a microcontroller for processing. We have used Arduino UNO as the microcontroller. The analog input pins are connected to the respective analog output pins of the MQ sensors. And the analog real-time data is processed by the Arduino UNO [4] containing the ATmega328P microcontroller. [5] The processed data is now transmitted through the Bluetooth wirelessly to the android smart phone with the application installed in it.

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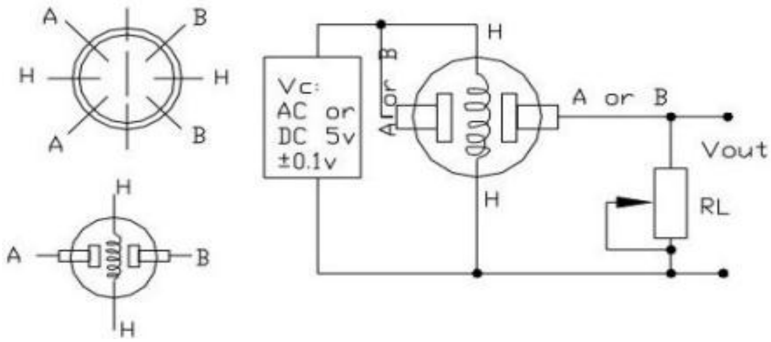

Figure 2 shows the circuit connections of a general MQ sensor.

The block diagram of the electronic nose is as shown in figure 3. It consists of an array of three sensors- MQ-4 [3], MQ-135 [4] and MQ-7 [5] for sensing hydrocarbons (HC), Carbon-dioxide (CO2), and Carbon monoxide (CO), respectively. These sensors are arranged in an array to record the emission parameters simultaneously.

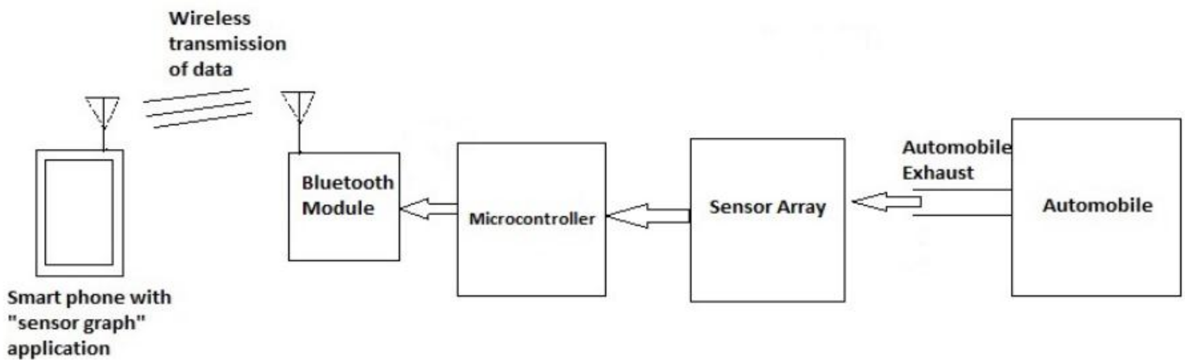

Figure 3 shows the block diagram of the electronic nose.

We have used Arduino UNO as the microcontroller to process the data output from the sensor breakout board. The analog output from the MQ sensor array is amplified using LM-393 and there is also provision for sensitivity adjustment. The analog output from the respective MQ sensors with breakout is given to analog ports A0, A1 and A2 of the Arduino UNO respectively.

V. ELECTRONIC NOSE (SENSOR ARRAY) COMPOSITION

The so-called electronic noses consist of chemical gas sensors that are able to monitor changes in the offgas composition of fermentation processes. The different sensors of electronic noses are based on conductive polymers (CP), metal oxide semiconductors (MOS), metal oxide semiconductor field effect transistors (MOSFET), or quartz crystal microbalance (QCM). CP-based sensors use the electrochemical properties of polymers like polypyrrole or polyindole. The absorbance of selected molecules of the off-gas into the polymer film causes changes in the sensors conductivity. MOS sensors possess an electrochemically active surface of metal oxides like tin oxide or copper oxide. The sensitivity of this type of gas sensors toward different inorganic (e.g., hydrogen, carbon monoxide, ammonia, hydrogen sulphide, nitrogen oxide, or sulphurous compounds) or organic compounds (e.g., alcohols and hydrocarbons) of the off-gas is modulated by the oxide composition, the amount of trace elements (e.g., palladium, gold or rhodium), and the temperature, which ranges from 100°C to 400°C. A MOSFET sensor is based on thin catalytic metal films covering a silicon oxide field effect transistor. The catalytic decomposition of organic and inorganic compounds on the surface causes shifts in the capacitance of the semiconductor device of this sensor. QCM sensors are able to measure the physical mass of a bound analyte. This is reached by determination of changes in the frequency of a quartz crystal by binding of the analyte to the sensor surface

VI. IMPLEMENTATION

By placing the device near the exhaust of the automobile, one can monitor the emission readings on the Smartphone using our android application. A provision is given in the smart phone application to enter the registration number of the vehicle whose emission is being monitored. A graph of time v/s amplitude of the emissions (CO, CO2 and HC) is plotted. CO and CO2 are represented in %vol and HC is represented in ppm according to the present standards in India. Our device was calibrated according to the present industry standards of measurements and our device faithfully matches the

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accuracy of that of the present device. The threshold values of these gases placed by the government is as shown in Table I and electronic nose is capable of issuing a warning in case the emission levels of a vehicle being monitored is higher than the threshold value.

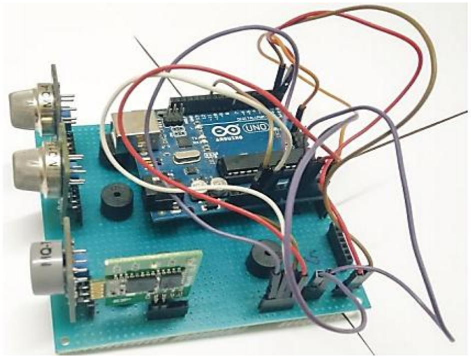

Figure 4 shows our model which is calibrated according to industry standards.

VII. RESULTS

Figure 5 shows the output for a vehicle with registration number KA 05 P 8633.

As we can see, the compact and accurate report generated by the electronic nose and displayed wirelessly using "sense_graph" android application. This report is saved in the SD card along with the vehicle number. Figure 5 shows the output for a vehicle with registration number KA 05 P 8633.

VIII. CONCLUSION

We have designed a device named the "Electronic Nose" which is portable, low cost, wireless, rechargeable, compact and easy to use so that monitoring of emission levels of automobiles becomes easier thereby keeping a check on vehicular emissions and its grievous effects on the environment and living beings. The use of android application instead of other output devices can revolutionize the current system of monitoring the emission data.

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