**CHEMICAL ENGINEERING TRANSACTIONS** Volume 23, 2010
Editor Renato Del Rosso

DOI: 10.3303/CET1023027


# WiNOSE: wireless electronic nose for outdoors applications

J. P. Santos, M. Aleixandre, M. C. Horrillo
Instituto de Física Aplicada (CSIC)
C) Serrano 144, Madrid (Spain)

In this work we describe a novel portable electronic nose. It is a battery powered instrument with wireless communications capable of stand alone operation for long time periods due to its low power consumption and its recharging possibility by installed solar cells. It has been designed to accept several types of resistive microchemical sensors limited only by their power consumption.
The instrument is made of low power, low cost industrial elements and basically comprises electrovalves, pumps, filters, a flowmeter, chemical sensors, solar cells and electronics for measurement, control and communications. The electronic nose can be operated stand alone or controlled externally by a personal computer. The wireless communications are based on the IEEE 802.15.4 *ZigBee* standard. Although this device has been developed for outdoor applications as off-odour or contaminants mapping it can be used as a general purpose low cost electronic nose. In fact, first application has been the detection of chemical warfare agent simulants and VOCs.

## 1. Introduction

There are a wide range of commercial available electronic noses (see the excellent review by Röck et al (2008)). Among them there are only few examples of wireless electronic noses. The utility of these instruments is evident in applications where gas monitoring has to be performed on locations of difficult access. Research efforts are made to develop compact wireless devices for real time quantitative analysis of gas mixtures (Cho et al., 2008). However none of these devices can be considered a stand alone instrument capable of continuous operation for long periods of time. We have developed a wireless low cost electronic nose (WiNOSE) which can operate for long periods of time without maintenance thanks to its solar cell rechargeable battery.

## 2. Instrument description

A schematic of WINOSE is shown in figure 1. It consists of two gas inlets that are switched through a three way electrovalve (SMC S70_ES) whose output is connected to the sensors cell that contains the microsensor array (a photograph of the low volume microsensor cell and the two microsensor arrays used is shown in figure 2).

Please cite this article as: Santos J.P., Aleixandre M. and Horrillo M.C., (2010), Winose: wireless electronic nose for outdoors applications, Chemical Engineering Transactions, 23, 159-164
DOI: 10.3303/CET1023027

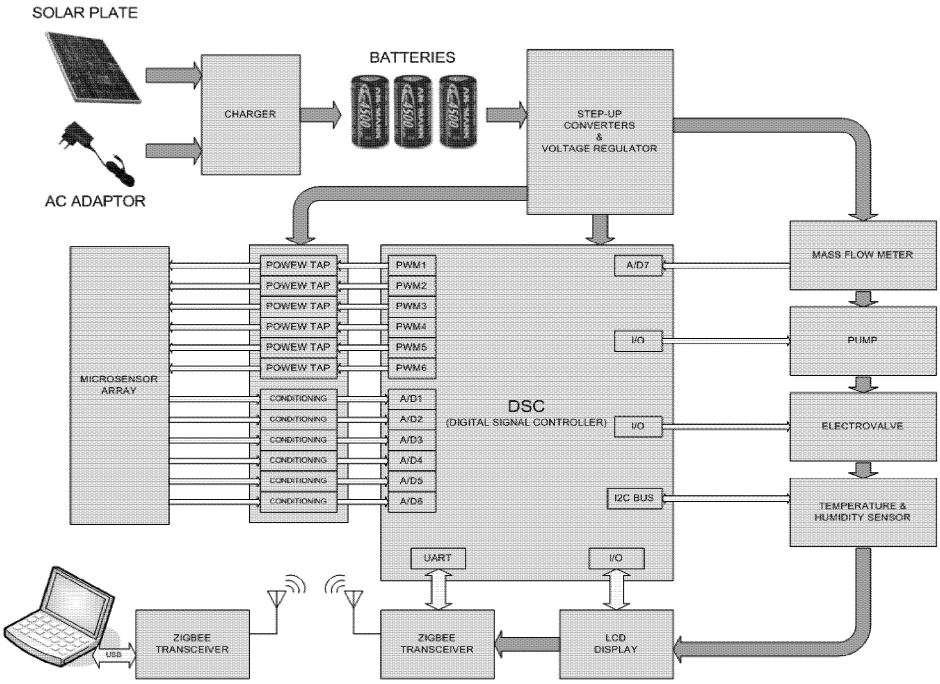


*Figure 1. Schematic diagram of WiNOSE*

One of the gas inlets has a carbon filter and is intended to provide clean air as reference baseline. Downstream are located the humidity and temperature sensors (Sensirion SHT15), the pump (Rietschle Thomas model 2002) and the flowmeter (SMC PFMV5). The whole system is controlled by a digital signal controller (DSC Microchip model dsPIC33FJ128GP306). It is a 16 bit microcontroller with 16 Kb of Ram and 128 Kb of FLASH memory. It has several analog to digital converters (A/D) inputs for sensor measurements and several pulse width modulation (PWM) outputs for sensor heating. Main measurement parameters are shown in a LCD. Wireless communications are provided by a IEEE 802.15.4 (*ZigBee*) transceiver. It provides line sight communications up to 1 Km. The transparent cover allocates a 2 W solar cell panel. Beneath the electronic board two 4500 mAh batteries are placed. A second prototype with global positioning system (GPS) capabilities has been developed although not tested yet.

A photograph of the first WiNOSE prototype is shown in figure 3. This prototype has been designed for two types of resistive microsensor arrays: a commercial one by SILSENS (MSGS-4000) and one developed by our group in collaboration with the Spanish Microelectronic Centre (IMB-CSIC) (Gracìa et al 2001). The microsensor array consists of four or six thin nanocrystalline tin oxide layers deposited over micromechanized silicon hot plates. They can operate at different temperatures up to 500 ºC.

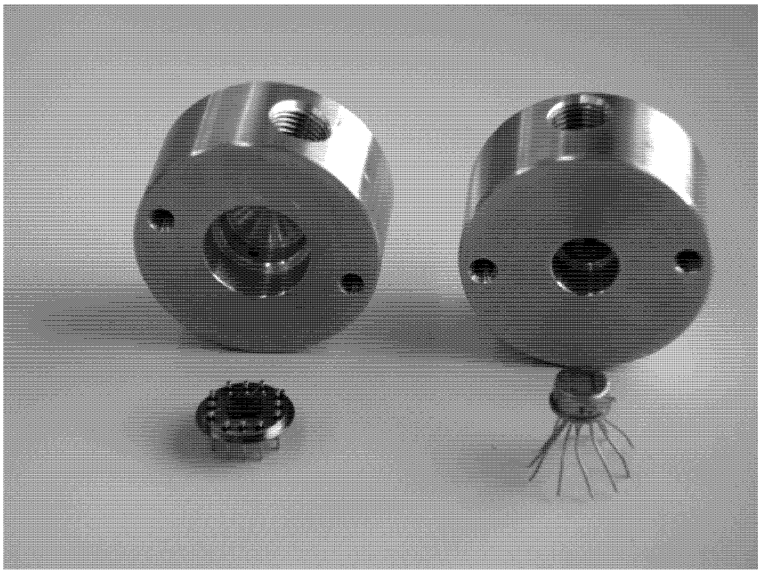

*Figure 2. Image of the sensor cell with the two microsensor arrays. In the left part the CSIC microsensor in a TO-8 package; in the right part the Silsens microsensor in a TO-5 package.*

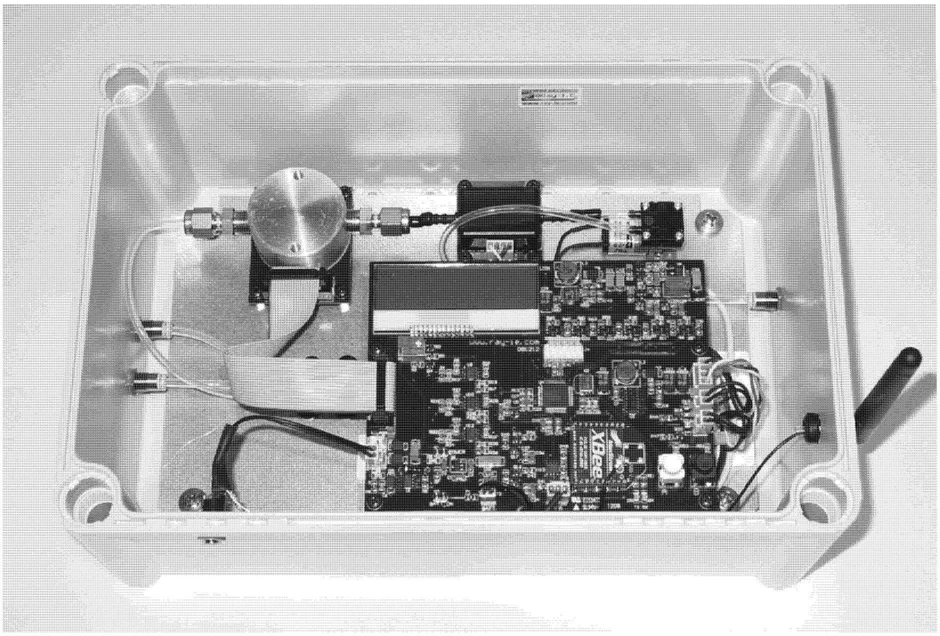

*Figure 3. Photograph of the WiNOSE first prototype. In the upper par it can be seen the sensors cell followed by the temperature and humidity sensor box and the pump. In the*

*lower part the electronic board. Beneath the board the electrovalve and the batteries are placed. The box cover with the solar panel is not shown.*

The measurement range of the sensors is shown in table 1.

*Table 1. Measurement range of the sensors*

| Parameter | Range |
|---|---|
| resistance | 10 - 5 x $10^7$ ohm |
| humidity | 0 - 100 % |
| temperature | -40 – 124 ºC |
| flow | 0 – 500 ml/min |

The instrument is controlled by a program developed in Testpoint, an instrumentation oriented programming language. A screen capture of the simplified user interface is shown in figure 4. In the bottom graph the resistances of the sensors are shown and in the upper graph the calculate responses are shown. The response is usually calculated as the ratio between the sensor resistance in filtered air to the sensor resistance at the end of the sampling time.

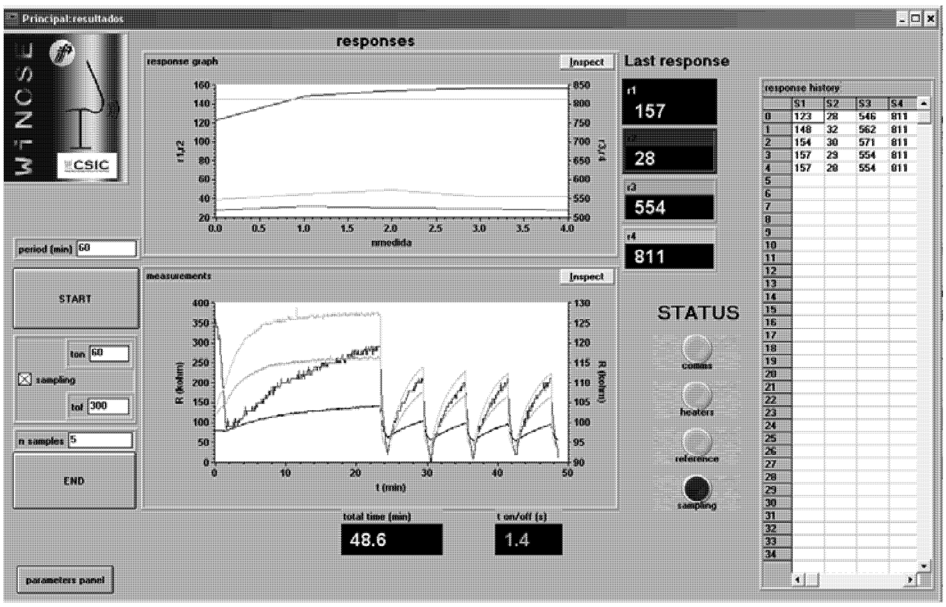


*Figure 4. Simplified user interface*

There are other two panels in the program. One that displays and control all measurement parameters (temperature, humidity, flow, sensor resistance, sensor temperature, valve status, battery status, pump setpoint, input and output communication messages) and other with the initial values (sensor temperatures, pump setpoint, communication settings) to send to the device when it comes out from standby. In order to extent the battery life it usually remains in a state of low consumption (*standby*) until it receives a valid read or write command when it activates to the *On* state. It will revert to standby by a specific command or when no message is received in a predetermined time lapse.

## 3. Results

WiNOSE is capable of eight hours of continuous measurements under dark conditions. Operating intermittently (10 minutes *On*, 50 minutes *standby*) and under daylight conditions it can provide measurements over a week. This is very useful to obtain measurements in locations without power supply or in travelling situations.
The system equipped with our microsensor array has been tested in laboratory with chemical warfare agent simulants. The commercial microsensor composed of four tin oxide sensors as well has been tested with volatile organic compounds such acetic acid, acetone and ethanol.

### 3.1 CWA simulants

Figure 5 shows the response of the microsensor array to several expositions of 5 ppm of DPGME (a simulant of nitrogen mustard) and to 0.5 ppm of DMMP (a simulant of sarin) in air. In both cases the individual sensors operate at temperatures between 229 ºC and 377 ºC. Flow rate was set at 200 l/min. Sampling and recovery time were 20 minutes. It can be noted the excellent response reproducibility and system stability. For these compounds the sensitivity increased with temperature.

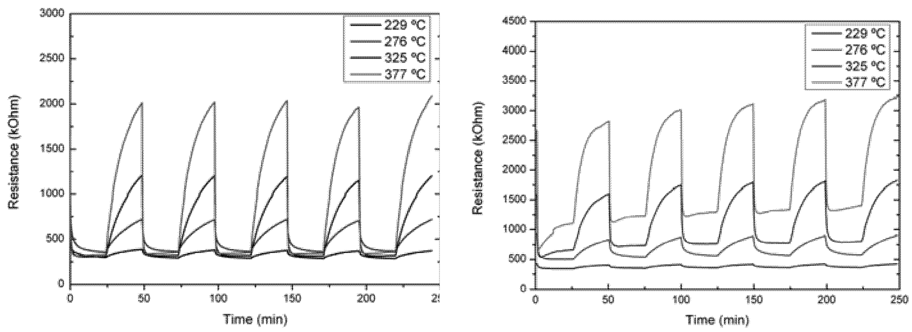


*Figure 5: Response of the microsensor array to 5 ppm of DPGME (left) and 0.5 ppm of DMMP (right). The first 20 minutes are the exposition to the gas and the following 20 minutes the recovery, then the cycle is repeated four times more.*

### 3.2 Volatile organic compounds

Solutions of 10 % v/v of ethanol, acetic acid and acetone in water have been measured together with pure water. The sensors operating temperatures were 150, 200, 250 and 300 ºC. Flow rate was set at 150 ml/min. Sampling time was 60 s and recovery time 360 s. Nine replicates of each compound were performed. Principal Component Analysis was carried out on these measurements. Figure 6 shows the score plot for the three first principal components. Data clusters are well separated.

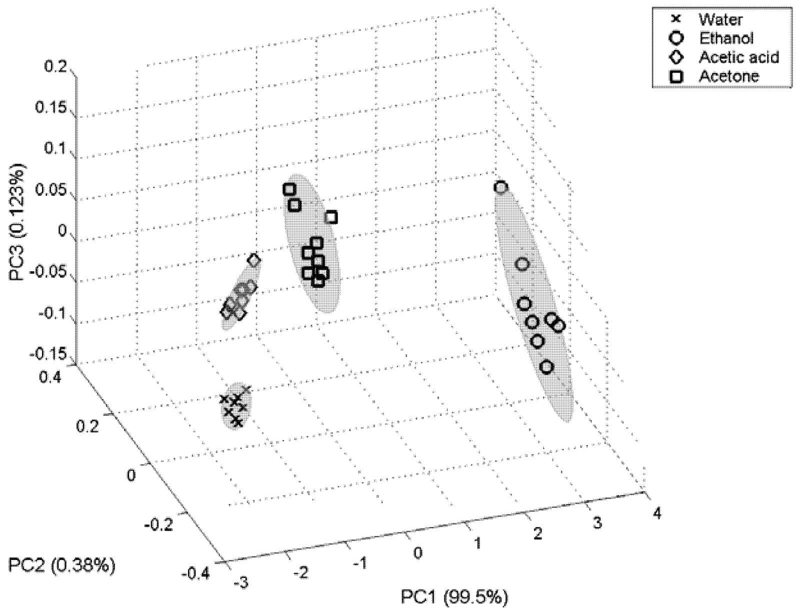


*Figure 6. PCA plot of the VOCS measurements with the commercial sensor array*

## References

Cho J. H., Kim Y. W., Na K. J., Jeon G. J., 2008, Wireless electronic nose system for real-time quantitative analysis of gas mixtures using micro-gas sensor array and neuro-fuzzy network, Sensors and Actuators B 134, 104–111.

Gracìa I., Santander J., Cane C., Horrillo M. C., Sayago I., Gutierrez J., 2001, Results on the reliability of silicon micromachined structures for semiconductor gas sensors, Sensors and Actuators B 77, 409-415.

Röck F., Barsan N. and Weimar U., 2008, Electronic nose: current status and future trends, Chem. Rev. 108, 705-725.