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# Towards the Miniaturization of Electronic Nose as Personal Measurement Systems †

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This study addresses the development of a miniaturized wireless sensing module (electronic nose) for a personal use in air quality detection. The proposed prototype has been developed as a test device for digital gas sensors and it includes 4 different: BME680 from Bosch Sensortech, CCS811 from Cambridge CMOS (ams), iAQ-Core from AppliedSensors (ams) and SGP30 from Sensirion. The core of the system is based on a high performance 32-bit microcontroller, model PIC32MM0256GPM048, from Microchip. The obtained data values are transmitted to the Smartphone through a Bluetooth communication module.

## 1. Introduction

As an alternative to classical analytical instruments, the combination of non-specific gas sensors with enhanced features (low cost, low power, low size) combined with pattern recognition methods could develop largely portable intelligent systems. This approach will allow for massive, distributed and ubiquitous measurements of atmospheric contaminants of the spatial and temporal resolution. This new generation of intelligent detection systems (based on the use of smartphones and other smart devices) will enable the citizens to monitor the quality of the surrounding atmosphere or use them as personal assistant to monitor diseases through the breath or test the quality of food and beverages; then, when necessary, taking measures in order to protect their health and wellness. In this sense, enhanced characteristics are required to the main components needed to develop these personal systems, e.g., low size and consumption sensors for the integration in very small and portable measurement systems, instrumentation and control systems with high precision and repeatability, low consumption and size with communication capabilities. Last but not less important, a machine learning system based on cloud or remote computing could be employed for signal and data processing of sensors and to save the computing power of smart devices used for control and monitoring.

In the last years, an important evolution of gas sensors has occurred from tube-type gas sensor of the 80's (Figaro and FIS among others) with a size higher than 17 mm diameter and a consumption of hundreds of mW to the latest commercial devices. Nowadays, MEMS based gas sensors (Figaro TGS1800, ams CCS801), Sgx Sensortech can be found in the market with a very low size (3 × 4 mm) and consumption (less than 15 mW). Other interesting sensors for integration in small and personal measurement systems are multisensor arrays with digital communication (via I2C or SPI interface). The main purpose of this work and of the device developed and showed in Figure 1 is to test these devices and analyze the response obtained from the digital sensors.

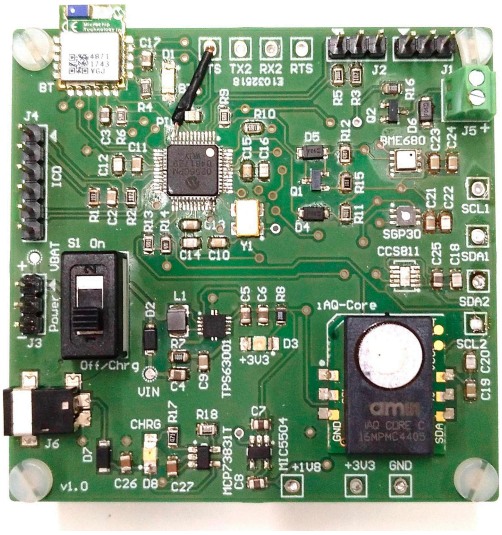


**Figure 1.** Image of the proposed electronic nose.

## 2. E-Nose Description

The sensor module is controlled by a microcontroller and it includes two power supplies (3.3 V and 1.8 V), a battery charger, a Bluetooth module and four digital sensors. It also has two UART ports (one of them to communicate to others 3.3 V devices and the other one to 5 V devices) and a terminal block for a solenoid valve connection. The block diagram of the module is depicted in Figure 2. The core of the system is based on a high performance 32-bit microcontroller, model PIC32MM0256GPM048, from Microchip. It has up to 24 analog to digital (A/D) 10/12-bit input channels, 256 Kbytes of program memory, 32 Kbytes of data memory, 9 Capture/Compare/PWM (CCP) modules, 3 Inter-Integrated Circuit (I2C) modules, 3 Universal Synchronous Asynchronous Receiver Transmitter (USART) modules, and a maximum operating speed of 25 MHz. The communications module is a Bluetooth 4.2 Low Energy module, the RN4871 from Microchip. Among its main features include UART Transparent Service for serial data applications, ASCII command interface API over UART and a compact form factor (9 mm × 11.5 mm) with an on-board ceramic chip antenna.

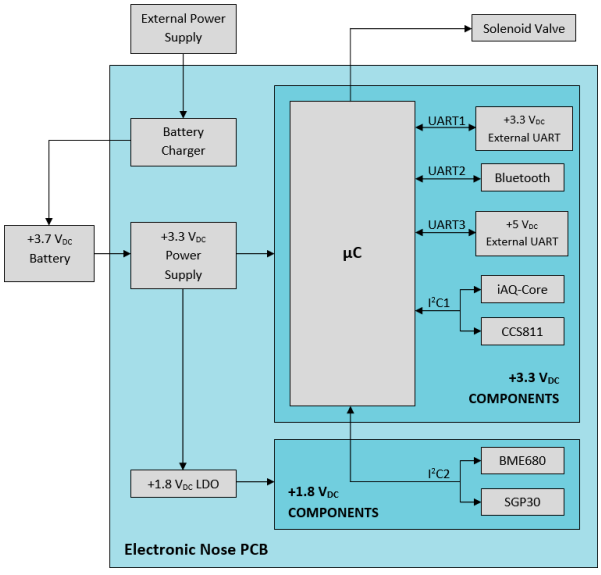


**Figure 2.** Block diagram of the electronic nose.

## 3. Results

Three of the sensors, CCS811, iAQ-Core and SGP30, return processed data of signals, but BME680 returns unprocessed data of signals, so additional processing of the signal is needed. As an example, different measurements with volatile organic compounds are made in order to test and analyze the response of the through I2C communication between the microcontroller and the sensor. These sensors provide the data in only one command communication. Depending on the model of the sensors, it sends the concentration of CO2 (ppm), then the status of the sensor, the value of the sensor gas resistance (kΩ), and finally the concentration of volatile organic compounds (ppb), temperature, humidity or pressure data, and also some or all of them.