IAQSense
Air Quality in Closed Environments

HIGHLIGHT – Demo Boards and Development Kits

August 31, 2016

Real-Time Indoor Air Quality Monitoring – The IAQSense Technologies are Coming on Demo Boards and Development Kits

Real-time monitoring of indoor air quality has been driving the technology development throughout the IAQSense project.

It has now been demonstrated on boards which provide access to the features of the different technologies for applications in VOC indoor monitoring, chemical threat detection and health monitoring.

Five boards are available for the utilisation of results, the development of applications and the preparation of the market introduction – with particular emphasis on the growing trends towards IoT applications.

For faster implementation and connection to IoT channels, all boards are hardware and software compatible with RaspBerry PI 2 / PI 3.

The basic software (drivers, initialization, data acquisition) has been developed for Windows 10 - IoT installed on RaspBerry PI.

The Five Demo Boards - Overview

The IAQSense project has developed 5 demo boards:

- 2 reference boards using components for sources external to IAQSense
  - IAQcore based board for detection of TVOC and CO2
  - MSS board using a network of 8 surface stress membranes
- 3 boards using IAQSense technologies
  - Spectrometer on chip + processing ASIC
  - Cantilever based network of 8 resonating cantilevers plus processing/actuating ASIC
  - Cantilever based network of 8 resonating cantilevers plus FPGA based lock-in amplifier.

The following technologies developed by IAQSense are used on the boards:

- Spectrometer on chip developed and produced by Nano Analytik (P and Ntype)
- ASIC IM452A for spectrometer on chip developed by Id-Mos (Xfab foundry)
- ASIC IM309D for cantilevers network developed by Id-Mos (Xfab foundry)
- Optionally a TIP transistor can be packaged for interfacing IM452A on the same board and realizing an enhanced spectrometer or a field sensing probe (Kelvin probe).

The attachment of the board to a Raspberry PI provides embedded solutions for

- Drivers, initialization and data acquisition
- Neural network or AI event identification
- Pattern recognition based on event libraries
- Firmware development, compilation, and downloading in case of IM452A ASIC with embedded µC.

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The following solutions are recommended for knowledge processing and pattern recognition:

- MatLab and neural network toolbox
- Weka and machine learning algorithms (Random Forest and derivates).

Solutions for software/firmware development:

- MSP430 development and debug: GNU Compiler Collection (GCC) for Spectrometer ASIC firmware development
- Windows 10: Visual Studio 2015 for all RaspBerry PI drivers

The Five Demo Boards - Details

1) IAQCore Based Board

Application Features

The application is in charge of driving the HW

- To initialise the display + IAQCore chip + leds + buttons
- To launch a periodic timer to read the IAQCore data (5mn power-on, then 1s rate of output data)
- To store the measurements in a file in CSV format. The data is stored as a CSV file on the FTP server of the board.

Red and green LEDs display the state of the TVOC and CO2 trigger levels and blink at different speeds showing the change trend.

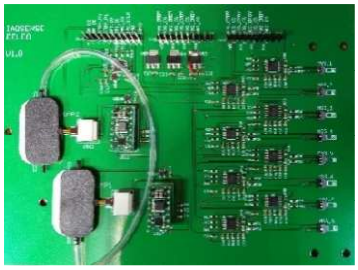
Buttons: button 1 for new storage session – button 2 clears all the stored files.

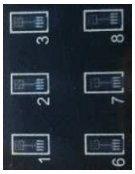
Display (on an external screen): state of the sensor (ready or not) – revalue – TVOC and CO2 level.

2) MSS Network Board (8 Stress Membranes)

Features

This board has an 8-channel MSS with input connectors for silicon membranes.





Each membrane can be changed and functionalized (DIY polymer deposition) and is accessible inside the injection chamber (on top of the 8 sensors).

Each channel has a separate ADC and DAC for managing sensor bridge amplification, offset compensation and conversion (16 bits).

2 electrostatic pumps (on board supplied and driven) provide static or dynamic flow of analytes and purge for static pattern analysis or dynamic slopes analysis.

One pump is driven to feed the pollutant, the other feeds the fresh air alternatively.

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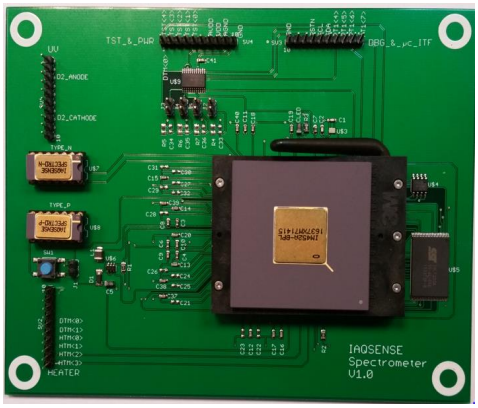
Application Features
The application is in charge of driving the HW

- to initialise the different devices
  - Chip select for the different ADCs of the membrane sensors
  - Interrupts of the different ADCs (data ready)
  - Driving of the pumps
- to define the default DAC values for each sensor
  - Before launching a measurement campaign, the MSS voltage offset is compensated
- to launch a measurement campaign for each of the 8 sensors

The global cycle is 60s split in 30s of pollutant feeding and 30s of fresh air feeding (100k samples per MSS membrane).

Data is stored in CSV format for further analysis on the ftp server.

3) Spectrometer on Chip Demo Board



Features
This demo board supports 4 sensors:

- 2 type P sensors + 1 type P sensor reference
- 2 type N sensors + 1 type N sensor reference

A processing ASIC (IM452A) drives the sensors, acquires the signal from each sensor and provides processing thanks to the embedded µC (MSP430).

An external flash and RAM are added on the board to store the program and one dataset.

Software
The software is installed on RaspBerry PI and provides initialization, parameters setting and firmware downloading.

Initialization

- Initializes the acquisition parameters (sensor parameters, sequence and acquisition speed)
- Provides transparent mode (learning mode)
- or full acquisition and compression mode with pattern recognition.

Downloading

- Downloads firmware developed offline, and
- database prepared on the base of learning under gas generator.

Principle of learning and pattern recognition

- Using Matlab Neural Toolbox or Weka machine learning, under gas generator with different set of gases. Extraction of key events.
- Downloading reference events in IM452A for real-time pattern recognition.

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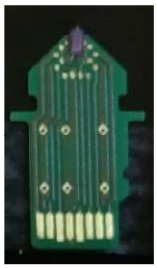
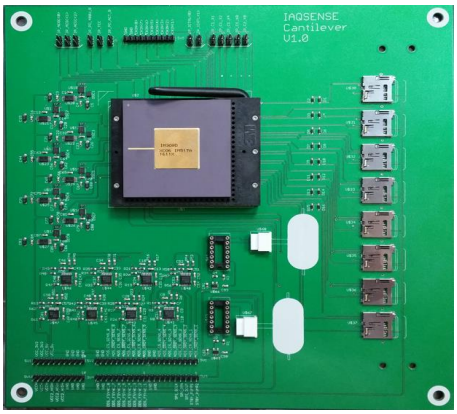
4) 8-Cantilever Network with ASIC Detection

This demo board supports 8 resonating cantilevers (100 kHz).





The ASIC (IM309D) acquires, filters and detects the 8 signals from each cantilever in parallel. It provides the driving of each cantilever with separate driving sine waves on the individual resonating frequency (thermal actuator).

A set of 8 ADC and DAC insures dataset acquisition and analogue settings while a set of 8 function generators provides the sine wave for the actuators.

Each cantilever is delivered with a surface coating with CuO nanotubes for extended surface and sensitivity and is individually accessible for further individual functionalisation (additional surface coating). It provides very sensitive detection and selectivity at ppb levels of concentrations.

2 electrostatic pumps provide injection/purge for dynamic detection of events due to molecules on top of the static detection providing means for further selectivity and uncertainty lifting.

Software

On the RaspBerry PI the software provides

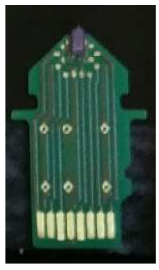
- The search for resonating frequency on each cantilever and further setting of function generators
- Initialization and data acquisition

Principle of learning and pattern recognition

- Using Matlab Neural Toolbox or Weka machine learning, under gas generator with different set of gases. Extraction of key events in static mode or synchronised dynamic mode.

5) 8-Cantilever Network with Lock-in Amplifier

A separate board has been developed using a digital lock-in amplifier to provide further improvement of S/N ratio for below ppb detection.



It uses the same set of 100 kHz coated cantilevers that can be further functionalized.

It serves, with the other cantilever, as a base for further study of CMOS integration and very low concentration detections.

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