

## PDA BASED VIRTUAL MEASURING SYSTEM FOR BROADBAND AIR QUALITY MONITORING

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**Abstract:** The paper presents the implementation of a low cost, small size portable measuring system based on a personal digital assistant (PDA) for indoor air quality monitoring. The virtual system is based on a compact flash data acquisition board (CF-DAQ), plugged-in the PDA, that provides a set of analogue inputs used to read the voltages associated with temperature, humidity and broadband air quality sensors. The acquired voltages corresponding to the air conditions of individual rooms or vehicle cabins under observation are processed at the PDA level using the LabVIEW software that assures the voltage to air quantity conversion (VAQc) using techniques such as look-up tables and polynomial or neural network inverse modelling. A comparison between the above mentioned conversion techniques are considered. Information from the sensors can also be recorded in the PDA memory (quite limited) or in the building room air quality monitoring in a personal computer that are Wi-Fi connected to the PDA..

Keywords: environmental measurement, mobile virtual instrumentation, air quality, humidity, temperature

### 1. INTRODUCTION

One of the greatest concerns of today's policies is the health and safety of the occupants of buildings or vehicle cabins. Air quality is a key factor. Together with temperature or humidity normally related with air conditioning system parameters, the "on-line" monitoring of air contaminants is very important and assures the people safety at work, in their cars or in their houses.

Referring to the indoor building "on-line" monitoring, it offers a number of important benefits including energy savings through demand-based control of outside air intake, improving and optimizing the air quality of the facility and identifying potential air quality problems in early stages.

Related with the air quality of vehicles' cabins, it should be mentioned that even if the air quality standard have forced world automakers to regulate automotive emissions, not much attention has been paid to air inside the vehicle's cabin other than ensuring that it remain at comfortable temperature, nothing about air contaminants. Even with the boom of the sensor technology only some luxury vehicles present interior air that is not only climate controlled but also free of harmful pollutants and unpleasant odours. Expensive "electronic-nose" systems are associated with

these air quality systems.

The present work presents a mobile solution for air quality monitoring based on a PDA with a compact flash data acquisition system and a set of three integrated sensors for temperature, humidity and global information of air contaminants. The system permits the "on-line" processing of the information delivered by the sensors, low rate data recording (caused by PDA memory restrictions), and Wi-Fi data transmission.

### 2. OBJECTIVE

The objective of the paper is to present a PDA based virtual system for "on-line" indoor air quality monitoring. Special attention is granted to the acquisition control and data processing of the signals acquired from the system sensor channels, data logging and Wi-Fi data transmission. The mobility of the solution permits the utilisation of the system in vehicle cabins where the air inlet can be manually or automatically closed when the broadband air contaminants concentration is over the imposed limits (inlet close alarm). In rooms, the information provided by the PDA based air quality system can be used as input of the demand-based control of outside air intake made by heating, ventilating and air conditioning (HVAC). The communication between the PDA based system and HVAC is performed via Wi-Fi.

### 3. METHODOLOGY

The system is based on three integrated sensors, HIH-3610 for relative humidity, LM-35 for temperature and TGS-800 for air quality. The voltage signals delivered by sensors' conditioning circuits are acquired by NI CF-6004, 14-bit data acquisition board plug in PDA iPAq 2700 CF slot and processed on the PDA level. The block diagram of the mobile indoor air quality monitor system is presented in Fig.1.

The control of the acquisition, data processing of the acquired voltage signals, pollution alarm generation and Wi-Fi data transmission is performed at the PDA level. The associated software was developed using the LabVIEW PDA Module.

Referring to the data processing a set of voltage to air quantity processing blocks are designed and implemented for each measuring channel of the PDA virtual measuring system.

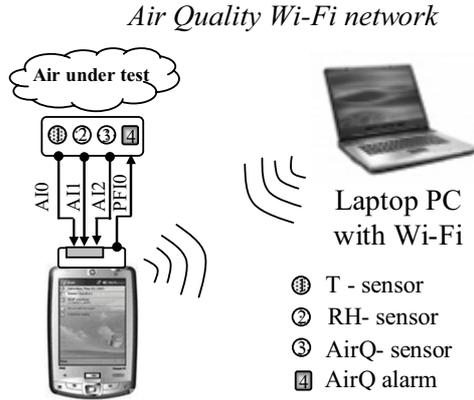


Fig. 1 Mobile Air Quality system based on PDA and CF data acquisition board

Thus on the temperature case considering the linearity error of the sensor (LM35 linearity) a first degree polynomial inverse model ( $T=P(U_T)$ ) is used. The voltage to RH processing block is represented by a rational form associated with RH temperature compensation:

$$RH_c = \frac{V_{RH} - V_{RH0}}{\alpha - \beta \cdot V_T} \quad (1)$$

$$U_{RH0}=0.958, \alpha=0.03237, \beta=0.00663$$

where the  $V_{RH}$  is the voltage acquired on the RH measuring channel and  $V_T$  represent the voltage acquired on the temperature measuring channel.

Regarding the processing block associated with air quality broadband sensor different type of methods were used in order to convert the voltage information in a pollution alarm informing about possible gas contaminants such as methane, carbon monoxide, isobutane, hydrogen, ethanol or cigarette smoke.

Using the voltage information associated with the sensor voltage divider ( $V_c$  – circuit voltage and  $V_{RL}$ -load resistor voltage for pollution conditions,  $V_{RL0}$  – load resistor voltage for clean air) the  $\zeta$  parameter, as input of air quality sensor processing block, is calculated:

$$\zeta = \left( \frac{V_c}{V_{RL}} - 1 \right) \cdot \frac{1}{\left( \frac{V_c}{V_{RL0}} - 1 \right)}$$

Three types of processing techniques were developed and tested in order to convert the  $\zeta$  parameter in air contaminants concentration: look-up table, polynomial and Multilayer Perceptron single-input single output neural network. Specific details will be presented in the final work.

The air pollution alarm is generated when the  $\zeta$  parameter decrease below an imposed pollution threshold (e.g  $\zeta \leq \zeta_{pollution}=0.2$ ). Based on imposed algorithm different possible contaminants at different concentration values (ppm) are displayed on the air quality tab of the PDA display that includes also the temperature (T) and relative humidity (RH) tabs (Fig. 2).

The alarm signal associated with the pollution event ( $\zeta$

lower than an imposed threshold  $\zeta_t$ , e.g  $\zeta_t=0.2$ ) is expressed by an alarm LED of the GUI AirQ screen tab. When a pollution event occurs, one of the digital output lines of the CF-6004, is set to “ON” which corresponds to the alarm command,  $AEv=“ON”$  (AEv-alarm event) that is sent to the alarm devices. At the same time the alarm command can be sent to the BAS in the indoor case or to the ventilation and air conditioning system in the vehicle cabin case.

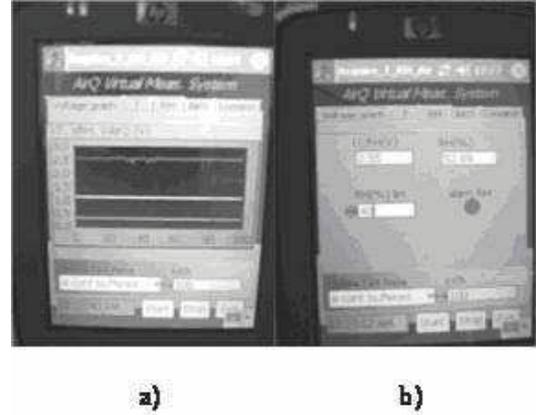


Fig.2. PDA Air Quality virtual measuring system – GUI: a) sensor voltage measurement channels display, b) RH monitor display with the LED RH alarm

In order to store information of air quality variation in time the values of temperature, relative humidity, gas concentration and pollution events are logged at the PDA level (SD memory) or are sent via Wi-Fi to the advanced processing and data storage unit represented by a laptop PC usually when an indoor air quality monitoring actions are carried out and the supervision is performed at an higher hierarchical level. (Fig.3)

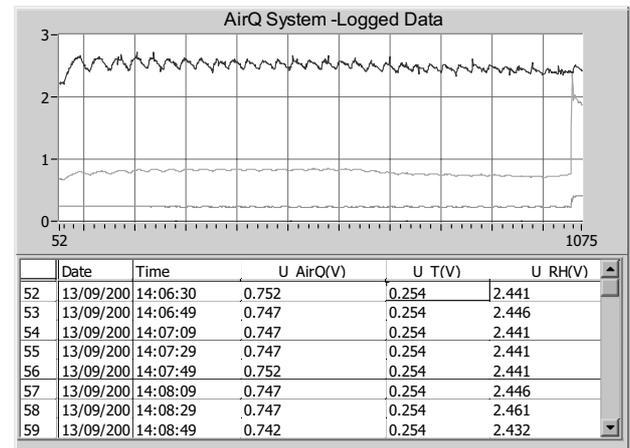


Fig.3. Air quality system – sensor voltage logging

#### 4. CONCLUSION

In this paper a virtual measurement system for indoor and vehicle cabins for air quality monitoring are presented. Elements of air quality sensor characteristics modelling, sensor fault detection and diagnosis, data logging and client-

server implementations using the LabVIEW PDA programming technique represent an important part of the work. A power consuming study is also performed.

The mobility and Wi-Fi communication capabilities assures the utilization of the presented system for vehicle cabins monitoring as so as the indoor air monitoring. Future work will be related with the utilization of a set of gas selective sensors and associated air contaminant concentration measurement.

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