Intelligent System for Monitoring the Environmental Parameters

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Abstract- *The project's idea is really simple: using the LabView environment, we have realized a virtual instrument able to get from the prototype data acquisition board for environmental monitoring parameters the information about air pollution factors like CO, H2S, SO2, NO, NO2 etc. In order to get effective information about those factors and the monitoring points, this intelligent measurement system, compound from portable computer, and Gas detector. This system can be used to map the information about the air pollution factors dispersion in order to answer to the needs of residential and industrial areas expansion.*

Keywords*: Virtual Instrumentation, Air Quality Assurance, prototype DAQB, intelligent monitoring system, TGS sensors*

I. INTRODUCTION

The EU-funded conference on "Environment, Health, Safety: a challenge for measurements", held in Paris in June 2001, recognized the need to improve the performance of environmental measurement systems and their harmonization at EU level, to foster the dialogue between the providers of measurement methods and the users of measurement results, and to prepare the base - by establishing special communication tools – for the integration of research expertise and resources of environmental monitoring across Europe. The concept presented herein aims to respond to this actual challenge by combining the latest software trends with the newest hardware concepts in environmental monitoring, towards providing reliable measurement results and representative environmental indicators, evaluating trends and quantifying the achieved results in order to manage the potential environmental risk in compliance with European legislation and local particularities.

In the actual development stage of the Romanian residential and industrial areas, the society demands more accurate and elaborated information in every domain. One of great interest is the air pollution filed. Over the last years, the clime changes have made the old prevision for dispersion of the air pollution around the industrial areas no longer accurate.

The atmospheric environment needs to be examined in consideration of the following three phenomena: global warming, ozone-layer depletion, air pollution.

Among these three, global warming is the most critical in terms of environmental conservation. Global warming is a result of greenhouse-gas emissions; therefore, to prevent it, greenhouse-gas emissions must be reduced. A major greenhouse gas is carbon dioxide (CO2). Therefore, reducing energy use, or saving energy, is the most effective way to help prevent global warming. There are some other gases that have a considerable influence on global warming. The first step to cutting the emissions of these gases as another environmental conservation measure is to monitor them in order to find a way to control them.

For this purpose, a new concept of performing high-speed data acquisition based on remote sensors, and an accurate transmission and processing of the meteorological parameters towards obtaining useful data for the users was developed in connection with the centre services. New methods of interconnecting hardware and dedicated software support were successfully implemented in order to increase the quality and precision of measurements.

In the same time, the Web concept itself is changing the way the measurements are made available and the results are distributed/communicated. Many different options are occurring as regards reports publishing, data sharing, and remotely controlling the applications. The LabVIEW environment was incorporated in centre concept towards creating a unique and powerful distributed application, combining together different measurement nodes and multiple users into a unique measurement controlling system, in order to integrate and revolutionize the fundamental architecture of actual PC-based measurement solutions.

The main objective of this work is to realize an intelligent system for environmental quality control and monitoring based on specialized sensors that are connected in a unit system [1].

II. SYSTEM ACHITECTURE

The hardware of environmental quality monitoring systems (sensors, conditioning circuits, acquisition and communication) must usually be complemented with processing blocks to perform different tasks associated to one-dimensional or multi-dimensional data that flow on the system measurement channels.
The architecture is composed as follows: the specialized sensors, detection circuit, a prototype data acquisition board by parallel port, PC-host. Using all this hardware we are able to perform a study for Taguchi-type gas sensors [2].

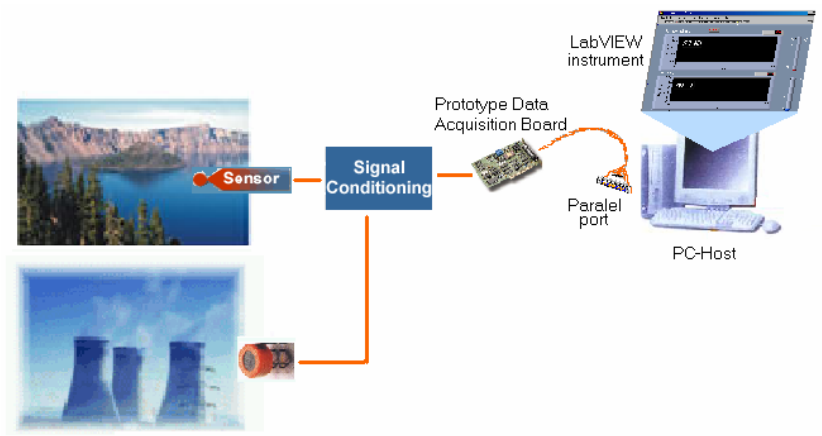

Fig.1. The architecture of the system.

The developed environmental monitoring systems (EMS) that use a prototype data acquisition board perform different tasks like: multi-sensors/multi-point measurement, continuum real-time monitoring, across limits warnings, save data etc.
Air quality parameters can be monitories, from interested areas like public places, enterprises etc. The desktop PC and LabVIEW software have the fallowing functions:

- DAQB control,
- Data processing and results display,
- Data storage and data administration
- User and warning beneficiar/utilizator,
- Analysis and decision etc.

A. The sensors module

The sensitive elements included in analyzed environment are metal oxide semiconductor mainly composed of SnO_2 and are tied to the EMS. These elements are heated at a suitable operating temperature by a built-in heater. Exposure of the sensor to a vapor produces a large change in its electrical resistance. In fresh air the sensor resistance is high. When a combustible gas such as propane, methane etc. comes in contact with the sensor surface, the sensor resistance decreases in accordance with the present gas concentration. Semiconductor gas sensors based on SnO_2 are widely used as safety monitors for detecting most combustible and pollution gases. However, most of the commercial gas sensors are not selective enough to detect a single chemical species in a gaseous mixture. It is desirable that a single sensor should be able to selectively detect several kinds of gases.
Recently, new methods have been proposed for chemical sensing that utilizes the analysis of the stochastic component of the sensor signal in Taguchi type sensors. It has been shown that even a single sensor may be sufficient for realizing a powerful electronic nose.
One of the problems appearing when we use sensitive elements like metal oxide semiconductor (SnO_2) is the temperature and humidity dependence of sensibility characteristic.

In this case the influences of physical environmental parameters must be compensated. The signal conditioning circuits associated with Figaro gas sensors (TGS813, TGS 822), have the function to convert ΔRs variation of sensor resistance in ΔV variation of voltage.
The change in the sensor resistance is obtained as the change of the output voltage across the load resistor (RL) in series whit the sensor resistance (RS). The constant 5V output of the data acquisition board is available for the heater of the sensor (VH) and for the detecting circuit (VC). The relationship between RS and VRL is expressed by the following equation [3].

$$V_{RL} = V_C \frac{R_L}{R_S + R_L} \tag{1}$$

The signal conditioning circuit is presented in figure 2.

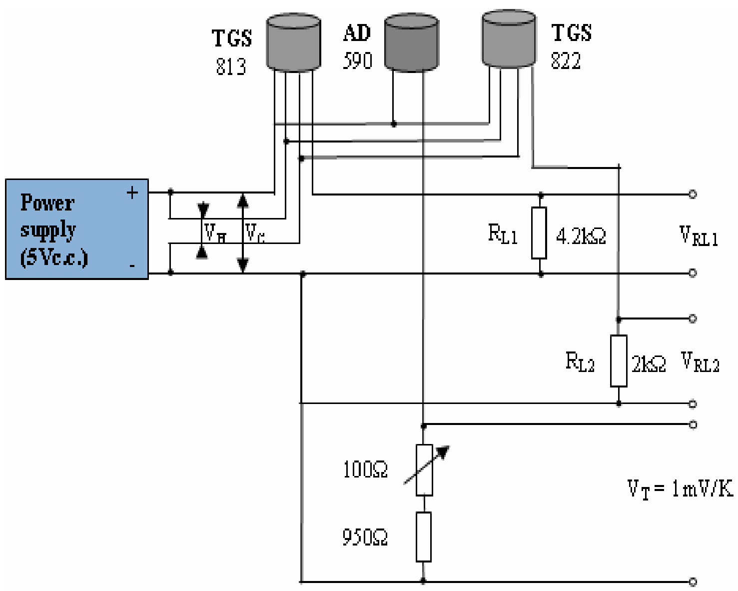

Fig. 2. Basic measuring circuit

B. The Data Acquisition Board

The LM12H458 are highly integrated Data Acquisition Systems. Operating on just 5V, combine a fully-differential self-calibrating (correcting linearity and zero errors) 13-bit (12-bit + sign) analog-to-digital converter (ADC) and sample-and-hold (S/H) with extensive analog functions and digital functionality. Up to 32 consecutive conversions, using two's complement format can be stored in an internal 32-word (16-bit wide) FIFO data buffer. An internal 8-word RAM can store the conversion sequence for up to eight acquisitions through the LM12H458's eight-input multiplexer. The LM12H458 can also operate with 8-bit + sign resolution and in a supervisory "watchdog" mode that compares an input signal against two programmable limits.
Programmable acquisition times and conversion rates are possible through the use of internal clock-driven timers. The reference voltage input can be externally generated for absolute or ratiometric operation or can be derived using the internal 2.5V bandgap reference.
All registers, RAM, and FIFO are directly addressable through the high speed microprocessor interface to either an 8-bit or 16-bit databus. The LM12H458 include a direct memory access (DMA) interface for high-speed conversion data transfer [4].

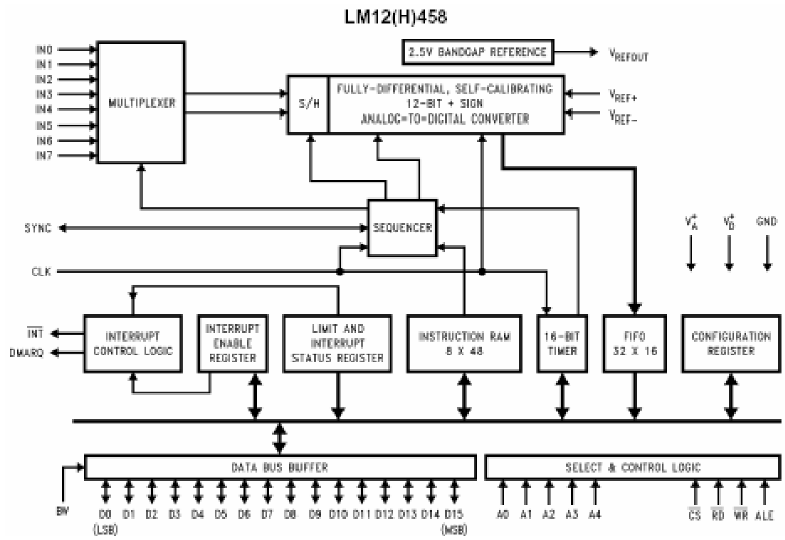

Fig. 3. Functional diagram of LM12H458.

III. THE VIRTUAL INSTRUMENT

The *virtual instrument* is the main part of the monitoring system and, in the same time the human interface, providing parameter controls. The main functions of the VI are:

1) SADI programming and communication control using Nr.Scan function from the specific functions palette.
2) data processing after data reading from SADI analog input channels
3) environmental temperature calculus starting from the analog input voltage(CH2) V_T.

$$T = V_T \cdot 1000 - 273{,}15 \quad [^{\circ}\mathrm{C}] \tag{2}$$

4) Sensors resistance calculus starting fromCH0 and CH1 read voltages (VRL1 and VRL2):

$$Rs = \frac{V_C \times R_L}{V_{RL}} - R_L \quad [\Omega] \tag{3}$$

5) Mean pollutant concentration calculus for a user presetting time interval (ppm/30min, ppm/8h, ppm/24h) for pollution level testing.
6) Pollution agent concentration limits exceeding verify for knowing the immediate effects fort health, lighting and voice user warning
7) Decrease the environmental temperature influence using a compensation subVI
8) Data base saving.

Admitting that the temperature and humidity have a great influence to Taguchi sensor resistance we have to make a compensation of the effect very utile when the system is used for outside. Knowing the R_S/R_0=f(T) dependency characteristic of the sensors and the temperature from AD590 temperature sensor the VI realize a temperature compensation by parts.

For example a R_S/R_0=f(T) TGS813 sensor characteristic is presented in Fig. 2. At 65% relative humidity, is made a characteristic linearization on the next intervals: -10ºC ÷ 20ºC, 20ºC ÷ 30ºC, 30ºC ÷ 40ºC. A slope determination for the three straight lines is done and for each temperature values is established the compensation factor. The main sub-VI's are:

1. *Nr.Scan* do the samples acquisition from an analog input channel.
2. *Vrl to RpeR0.vi* do the determination of Rs/R_0
3. *Compens_term.vi* realizes the compensation of temperature influence on sensor resistance (TGS). The VI inputs are: current temperature (ºC) and measured value of Rs/R_0 and the VI output is R_S/R_0 value after

thermo-compensation. The compensation of temperature influence is realized by equation implementation of linear variation $R_S/R_0=f(T)$ in temperature interval previously mentioned.

4. *R to Concentratie.vi* determine the methane concentration based on sensor measured resistance using the next equation:

$$G_s = S_0 \cdot C^b \tag{4}$$

where $G_s=1/R_S$ is the sensor conductivity at certain methane concentration C.
S_0, b – constants determinate for two concentration (C1=1000 ppm, C2=3000 ppm) when we know the value of sensor resistance. At VI input is applied the sensor resistance (R_S) after the thermal effect compensation obtaining to the output the calculated value of concentration.
Tens to grdC.vi give the temperature dependence on input voltage of analogical channel 2 (1m/K).

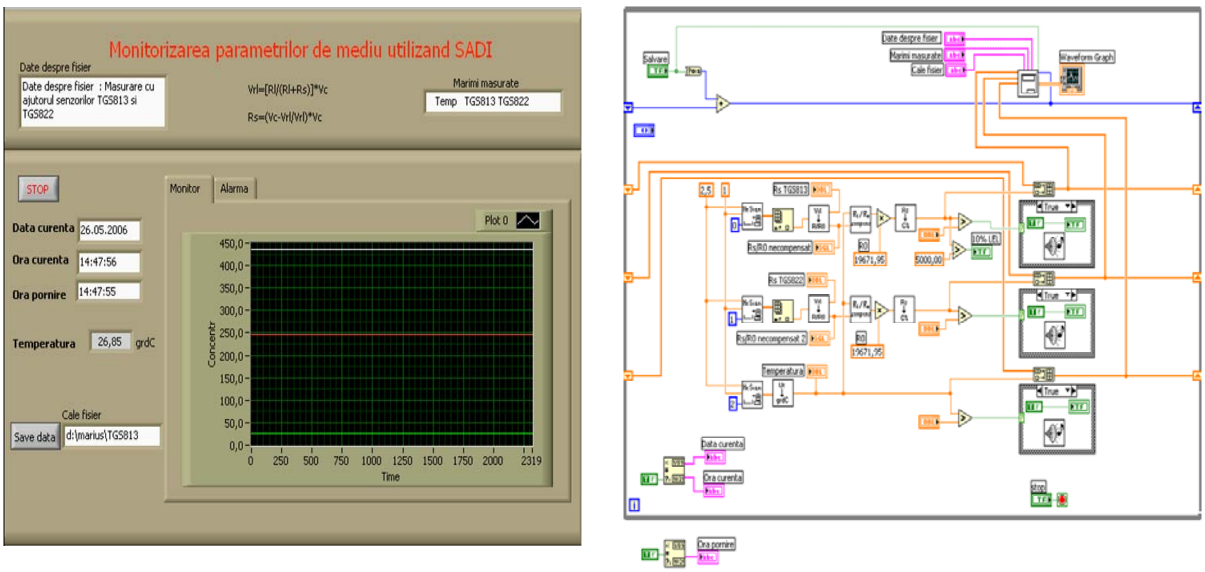

Fig. 4 . Front panel and diagram of VI environmental monitoring system using a prototype SADI.

However, in some situation is necessary the identification (recognize) of some gases compound with different smells using complex chemical analyzes.
If the imitation of tactile, additive and visual human senses and there implementation in tele-transmitting automat systems is well know in the literature, the smell sense was ignored. They are many applications where so called electronic nose may detect what is difficult or impossible for human or animal nose (for example, toxic waste identification, combustible mixture analyze, industrial emission monitoring, noninvasive medical analyzes, verification of food qualities, drugs detecting, mine and explosive detecting).
Intelligent system achievement witch is dedicated for particular application is not easy. It presume a selection of chemical sensors area witch provide a large information quantity and complex algorithms development for signal processing.

IV. CONCLUSIONS

The presented system constitutes a versatile, flexible, cheap, high-speed digital data acquisition system that combined with LabView software give the possibility to easily monitoring the environmental parameters. They are many applications where the system can be used like: toxic waste identification, combustible mixture analyze, industrial emission monitoring, noninvasive medical analyzes, verification of food qualities, drugs detecting, mine and explosive detecting.
This system can be adapted for an intelligent electronic nose with data transfer directly trough the internet. I named this system Web E-Nose.

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