Using Inexpensive Home Alarm for Computer Based Carbon Monoxide Monitoring

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***Abstract*— The current increase of air pollution rates and its consequences of global warming, health problems and threats to human lives necessitate the continuous search for more efficient and cost effective gas monitoring devices. Devices that is easily available and implementable worldwide. In developing countries the cost and the availability of the equipment is one of the obstacles that contribute to not having an efficient monitoring system. Hence, modifying cheap and easily available devices to work as pollution monitoring system will be an asset in this direction. In this work I am presenting the design of a computer based pollution detection and measuring system using cheap CO (Carbon Monoxide) alarms used in homes. The outcome is a cost-effective computer based CO monitoring system that is easily available and could be easily modified to work as a network based CO nose. A C# based program is also designed to show and log the sensor readings in an easy to use and read Window.**

Index terms-- CO detection, CO measurement, Gas pollution detection, Computer based measurement.

I. INTRODUCTION

During the last 50 years the industry has produced over 60,000 new chemical compounds which have accumulated in the environment and some of them bio-accumulated in the human body. Emissions of air pollutants disperse in the atmosphere and are transported at long distances from their sources. The medium in which the air pollutants are transported is the atmosphere, and its dynamics determines their lifetime and their impact on the environment and humans.

Many of these chemical compounds have been transported to the biosphere and are characterized as toxic or potentially harmful. One of these toxic gases is carbon monoxide (CO). Sources of carbon monoxide are combustion sources and indoors heating appliances (such as gasoline heaters and fireplaces). Vehicular exhaust as well as cigarette smoke is two additional important sources of carbon monoxide.

Elevated concentrations of CO have been measured inside vehicle cabins with values ranging between 9 and 56 ppm (parts per million). In the United States it has been shown that the ratio of CO concentration inside cars to its value outdoors has value close to 4.5. Exposure to CO at low concentrations results to tiredness of healthy persons and chest pain to people with heart problems. At higher concentrations there are problems with vision, headache, dizziness, confusion, nausea [1].

All above added to global warming issue necessitate that all the world together works to reduce gas emission. Air pollutants are not generated only by developed countries. Developing countries contribute to this by emitting a lot of pollutants to the air. The problem magnifies in these countries by the unavailability of monitoring and measurement tools. Sometimes the excuse is the financial capacity and in other cases is the inability of finding or using a suitable tool. The availability of an easy to use and cost effective tool will be the first step to remedy this situation.

II. SCOPE OF THE WORK

In this work I am presenting the design of a simple carbon monoxide gas pollution detection and measurement system. The concern is to carry computer based monitoring of carbon monoxide gas levels in indoor environments. This task is to be carried out using already available alarm systems to keep the cost of design minimum and to get benefit from the availability of these low cost devices.

Percentage of CO gas (pollutant) in indoor environment will be measured and the computer based system could be used to judge whether a room or a closed area pollution rate is above or below the average level.

To justify the aim of the work a literature survey of available devices and system is presented in the next two sections.

III. AVAILABLE DEVICES

Through searching the internet several devices that could be used for CO pollution measurement were found. Samples of these devices are described below:

The link HTTP://WWW.CONSUMERSEARCH.COM/CARBON-MONOXIDE-DETECTORS contains a description of different CO sensors. The price ranges from 35$ to 75$. These devices has no computer connectivity and there main use is to alarm when CO level raises to above acceptable levels.

Another device was found on Wikipedia at the link HTTP://EN.WIKIPEDIA.ORG/WIKI/FILE:DETECTOR_FOR_GAS.JPG. The brand is ITX and it monitors several gases but its connectivity to a computer system for data exchange was not clear.

IV. Literature Survey

Below are a literature review on related works in the field of pollution sensing and measurement. Most of the works are related to urban area pollution monitoring, modeling and measurement and device specific use and analysis are not available, which is the main aim of this work.

Boscolo et al. [2] describe the development activity of a mobile instrumentation devoted to city air quality monitoring. In particular the methods adopted for collecting and analyzing the air samples, the preliminary processing of the raw data coming from a solid state sensors array and the developed dynamic on field calibration procedure are discussed and the preliminary results obtained are reported.

Ando et al [3] in their paper describe a mathematical models for prediction of air pollutant levels, produced by industrial plants. A black box approach, for modeling air pollution is proposed. The main target of the models is prediction, on the basis of both meteorological forecasting and production policy, of pollutant levels. Sulfur dioxide is the main concern. It has been written (by the authors) that the integration of this model in an emission control scheme may represent a very useful approach to the air quality problem.

Andria et al. [4] present a study modeling air pollution measured data that are remotely sensed through appropriate instrumentation. Modeling is basically important in order to validate measured data. Spatial and bi-dimensional modeling to reduce uncertainty in recovering data have been used. A Gaussian model is used to study the possibility of decreasing recovering error by using mathematical parameters

Tsujita et al. [5] here the authors propose a gas distribution analyzing system (GASDAS). The use of gas sensors enables compact and inexpensive sensing systems, and will lead to a significant increase in the density of monitoring sites. As a first step in the development of GASDAS, nitrogen dioxide and ozone monitoring systems have been developed. The experimental results have shown that the low-cost sensor systems with signal compensation features for the change in weather conditions can be used for the quantitative measurement of spatial pollutant distributions.

[6] Presents the use of a dynamic gas sensor network for air pollution monitoring, and its auto-calibration to achieve the maintenance-free operation. Although the gas sensor outputs generally show drift over time, frequent recalibration of a number of sensors in the network is a laborious task. To solve this problem a dynamic gas sensor network is proposed. By placing sensors on vehicles running on the streets or placing some of them at fixed points and the others on vehicles. Since each sensor in the dynamic network often meets other sensors, calibration of that specific sensor can be performed by comparing the sensor outputs in such occasions. The sensors in the whole network can thus be calibrated eventually. The simulation results are presented to show that adjusting the sensor outputs to the average values of the sensors sharing the same site improves the measurement accuracy of the sensor network.

Branzila et al. [7] in their work present a 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 through the internet and it called Web E-Nose by the authors.

Morsi in [8] presents a case study for examining the use of sensor grid system concerning urban air pollution monitoring for carbon monoxide, carbon dioxide (CO_1 and CO_2) gases for three different regions in Alexandria- Egypt along the Corniche and 2 different traffic roads. This is based on the integration of distributed sensors, data integration and developing a simple air pollutant model. The analysis and the characterization of environmental data are acquired by building a prototype of multi-sensors monitoring system (electronic nose), which are TGS 822, TGS 2442, TGS 813, TGS 4160, TGS 2600, temperature sensor, humidity sensor and wind speed measurements. All sensors are connected to a microcontroller (PIC 16F 628A) and a PC to visualize and analyze data. Quadratic surface regression method is used to find possible correlations existence between some pollutants, elaborated by Matlab software and statistical analysis.

Jiang et al. [9] in their paper write about how to control air pollution at indoor of an automobile. Detecting concentration of the indoor noxious gas is precondition to make control measures. The infrared detector is used to test concentration of carbon monoxide and the carbon dioxide carbon inside of automobile, the pressure sensor to test pressure field. These test data could provide a reference for controlling air pollution, and then detection scheme has been given. According to the usual driving environment, that noxious gas flow inside of automobile is simulation analyzed, and different ventilated pattern impact to flow of noxious gas at the indoor of the automobile is discussed.

The work presented in [10] is a mobile system for air quality and pollution measurement suited for the urban environment. Based on authors quote “A reliable measurement device has been designed, tested and built”. The device can acquire information about the air quality of its surroundings, store it in a temporary memory buffer and periodically relay it to a central on-line repository. Real-time gathered data can be freely accessed by the public through an on-line web interface. Users can select and view different gases and concentrations overlapped on a map of the city.

V. CO ALARM SENSORS

During the search for CO alarm to use in this work, the use of two sensors in theses devices were noticed. The MQ7 and TGS 2442 sensors. The MQ7 [11] sensor is a gas sensor with a high sensitivity to Carbon Monoxide. The SnO2 of the sensor is with lower conductivity in clean air. It makes detection by method of cycle high and low temperature, and detect CO when low temperature (heated by 1.5V). The sensor conductivity is higher along with the gas concentration rising. When high temperature (heated by 5.0V), it cleans the other gases adsorbed under low temperature. The sensor could be used to detect different gases that contain CO, it is with low cost and suitable for different application.

Another sensor that is used is the TGS 2442[12]. The TGS 2442 utilizes a multilayer sensor structure. A glass layer for thermal insulation is printed between a ruthenium oxide (RuO2) heater and an alumina substrate. Pair of Au electrodes for the heater is formed on a thermal insulator (on an electrical insulator) to measure the sensor resistance. The gas sensing layer, which is formed of tin dioxide (SnO2), is printed on an electrical insulation layer which covers the heater.

The TGS 2442 displays good selectivity to CO, making it a good choice for CO monitoring. In the presence of CO, the sensor's conductivity increases depending on the gas concentration in the air. A simple pulsed electrical circuit operating on a one second circuit voltage cycle can convert the change in conductivity to an output voltage signal which corresponds to gas concentration.

VI. THE CURRENT WORK

In this work a cost effective computer based system has been designed to facilitate CO gas pollution measurement and monitoring through modifying a home based CO alarm. The system is composed of two hardware modules and one software module:

A- A CO alarm sensor.

B- A USB (Universal Serial Bus) interface board.

C- A software module.

The software module is a C# based program that reads the sensor data and show it in a graphical way for the user, it also logs the reading into a text file (COData.txt).

A. The CO Alarm Sensor

"Fig. 1" shows the used CO alarm sensor which is a home based device.

Fig. 1. The used CO sensor

This CO alarm uses the MQ7 sensor. This sensor requires alternating the heater voltage from low to high. In low it detects the CO gas and in high in clear the gas to start another cycle. Since, the alarm device contains all the necessary support circuitry for heater voltage toggling; there was no need to design any special circuit for that. A wire is connected to the sensor output voltage pin and brought out of the device. The other end of the wire is connected to a voltage divider and then to the USB interface card analog input pin. The PCB of the CO alarm is shown in "Fig. 2".

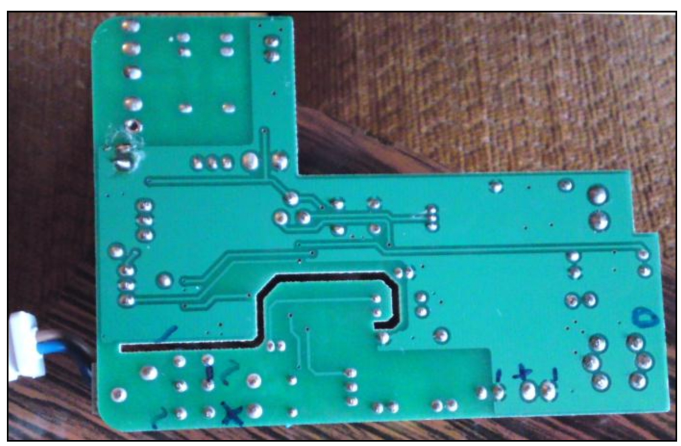

Fig. 2. The PCB of the CO Alarm

B. The USB Interface Board

Any USB card that has an analog input port can be used for reading the sensor data. The driver of the USB card allows engaging it to the C# program through special function calls provided by the USB card designer. The cost of the used card is about 45 USD.

C. The Software Module

The software module monitors the sensors reading in a continuous manner. The readings are shown in an easy to read Window. It shows the signal readings and the maximum value of the sensor reading "Fig. 3".

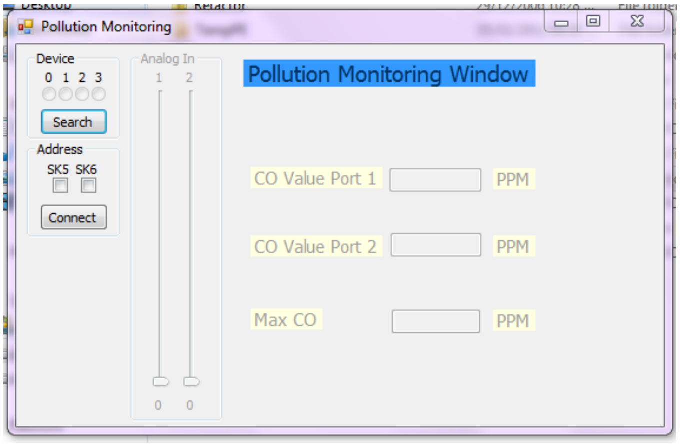

Fig. 3. Pollution Monitoring Window

The algorithm used to sense the maximum reading value works by tracking the MQ7 sensors voltage and signals the value as maximum whenever the readings are no more increasing. It works by comparing two successive readings values to judge whether readings are increasing or decreasing.

The program stores the readings, the time and the date of the reading in a comma delimited text file. The content of the text file could be easily converted to graphs through the use MS-Excel.

VII. RESULTS AND DISCUSSIONS

The system has been tested to detect amount of CO in an indoor environment. As a start "Fig. 4" shows the device's data logging when it's switched on. It's clear from the figure that about 2 minutes are required for the sensor to reach steady state. After that the sensor will have a full span from minimum to maximum.

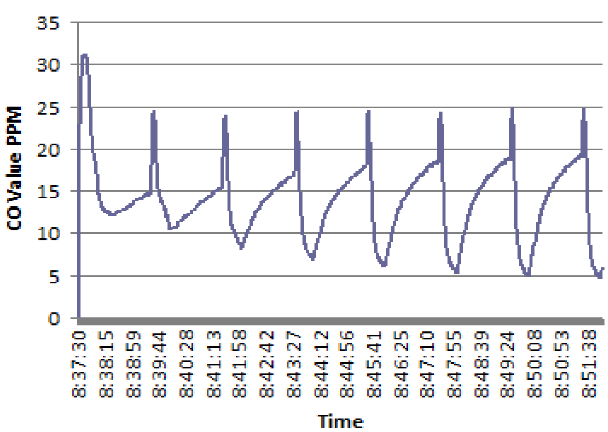

Fig. 4. Startup readings fluctuation with time

The maximum value represents the actual PPM calibrated to another meter reading that is equipped with a digital display.

"Fig. 5" shows a steady state reading for the device. The actual CO value in this case is 26 PPM.

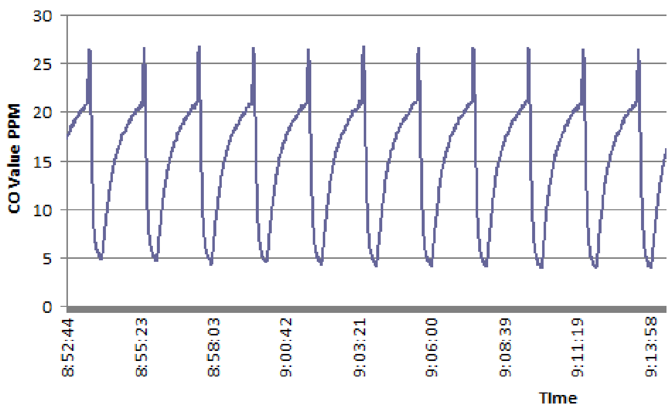

Fig. 5. Steady state readings with time

In "Fig. 6" and while the sensor is at steady state a cigarette smoke is brought close to the CO alarm by 4 cm. It's clear from the figure how the signal value is changing after 10:52 to reach 35 PPM.

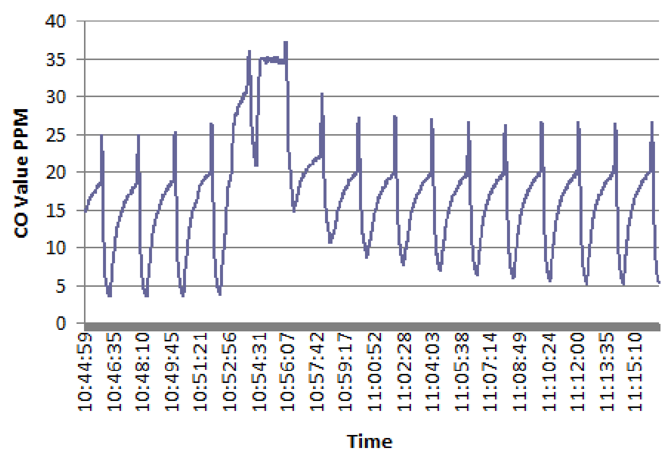

Fig. 6. Signal change while a cigarette is brought close to the sensor

"Fig. 7" shows the sensor steady state reading at the morning of a day. It's clear from the figure that the PPM is approaching 18 which is much lower than the values shown in "Fig. 5" which was for the sensor readings at the night.

These reading were taken at a two floor house. The season is winter and kerosene based heaters were used for heating the house. It was noticed that CO values are lower at the day start and increases as we are approaching the night. Values of CO at rooms on the first floor were higher than values of CO at the ground floor.

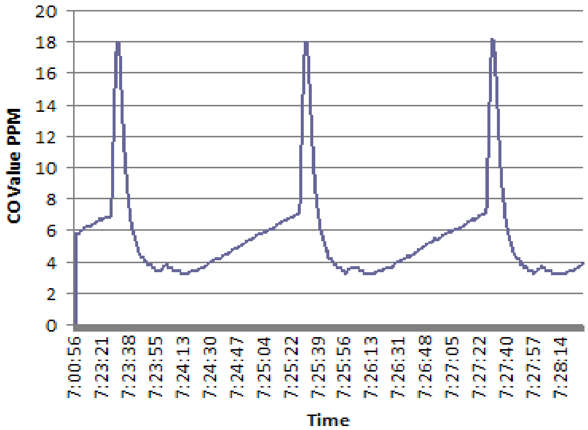

Fig. 7. Sensor readings at the morning of a day

The actual PPM for the readings shown in "Fig. 7" is 12, but in the figure the CO alarm shows a value of 18 PPM. This is due to that the MQ7 sensor is not sensitive for detecting low values of PPM.

VIII. Conclusion

In this work a cost effective computer based CO gas pollution monitoring system has been designed. The main features of the designed system are:

- Cost effectiveness. The approximate cost of a unit is about 70 USD. 25 USD for the CO alarm and 45 USD for the USB interface card.
- The cost effectiveness allows easy implementation of the system to work as a network of electronic nose for CO gas detection and measurement across buildings and urban areas.
- The unit is easily available and repairable (especially for developing countries) because it's composed from commonly used components. A cheap CO alarm and a USB interface card.
- Readings are logged inside a text file and logged data could be easily shown in a graphical way.

Although the results show that the used alarm's sensor is effective for wide range of carbon monoxide levels but it's not for low levels of gas amounts. This does not nullify the important of the work as having a low cost computer based measurement tool is better than not having it at all, and low values of CO is not dangerous for human health as moderate and high values. Using other alarms that are using sensors with wider operational range (like the TGS 2442) may enhance the low end sensitivity but at a higher cost value.

As it was written before the main goal of this work was to produce cost-effective and easily obtainable tool for pollution measurement. This is very important for developing courtiers (and even for developed) in which budget is one of the obstacles in a lot of projects implementations.

As a future plan, the goal is to establish a network of sensors (based on this system) to measure variation between sensor readings in different points in urban areas.

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