ISSN 1726-5479

SENSORS & TRANSDUCERS

vol. 112
1 /10

Sensor Instrumentation, DAQ and Virtual Instruments

International Frequency Sensor Association Publishing

IFSA

Sensors & Transducers

Volume 112, Issue 1
January 2010

www.sensorsportal.com

ISSN 1726-5479

Sensors & Transducers Journal (ISSN 1726-5479) is a peer review international journal published monthly online by International Frequency Sensor Association (IFSA).

Sensors & Transducers Journal

Contents

Volume 112
Issue 1
January 2010

www.sensorsportal.com

ISSN 1726-5479

Research Articles

Authors are encouraged to submit article in MS Word (doc) and Acrobat (pdf) formats by e-mail: editor@sensorsportal.com
Please visit journal’s webpage with preparation instructions: http://www.sensorsportal.com/HTML/DIGEST/Submition.htm

International Frequency Sensor Association (IFSA).

Sensors & Transducers Journal, Vol. 112, Issue 1, January 2010, pp. 80-94

Sensors & Transducers

ISSN 1726-5479

http://www.sensorsportal.com

Development of Laser LEDs Based a Programmable Optical Sensor for Detection of Environmental Pollutants

[*]Amit K. Sharma and R. K. Tiwari
Department of Physics, Hindustan College of Science and Technology
Farah, Mathura-281122 (U.P.) India
[*]Fax: +91-565-2763364
E-mail: amit_vashishtha1980@rediffmail.com

Received: 30 November 2009 /Accepted: 22 January 2010 /Published: 29 January 2010

Abstract: The laser LED based optical sensor and its multifunctional operation for detection of environmental pollutants are described. The work will provide the instructions to design of circuitry for optical sensor instrument with a program based on a microcontroller (8902051-24PI), and to allow this program to communicate via RS-232 with computer. An algorithm is outlined by which the sensor instrument can use three laser LEDs (blue, Green and red) to quantify the composition of pollutant. The operation of measurement through optical sensor has been applied to the study of detection and rate of reaction of pollutant i.e. methyl parathion and the produced informative data were also correlated with UV-vis spectrophotometry for the validation of results. The purpose of designed optical sensor is that the sophisticated analytical techniques show costly impact, time taking process, high consumable solvents and not suit for field application purpose which focuses the merits of the optical sensor. *Copyright © 2010 IFSA.*

Keywords: Laser light emitting diode, Photodiode, Data acquisition system (DAS), Pollutants, UV-vis spectrophotometer

---

1. Introduction

There is a need in many resources and laboratories for a handheld low cost analytical instrument that could provide both qualitative and quantitative chemical information. There are also great needs for low cost autonomous instruments that could help fragile environment around the world on a globe scale. With the advances in modern electronics, microcontroller could provide great capabilities to acquire and process sensor signals. Recently, the miniaturization of analytical instruments diverts the researcher's mind to develop a compact technology and to move sensing devices in every field of science. Generally, an optical device consists of two major components, a light source (such as color LEDs and laser LEDs) and a detector (such as phototransistor, photodiode, luminescent materials, photomultiplier tube and polymer sensing film) that recognize a particular analyte in its color assay and transmit total intensity from this assay into an electrical signal. The produced electrical signals are dependent on the nature of analyte in its assay and designed circuitry system including environmental conditions. Such type of thing is covered wide areas of science and also generates a circuitry of simple data acquisition system for the quantitative and qualitative analysis of analyte in its assay in different environments like soil, water and human blood, as reported in many analytical methods [1-7]. The concept of integration physics has different meanings include developing any analytical instruments like optical devices, optical procedures and optical work systems. Typical objectives for sensor devices include simplification, reliable, reproducible results, speed, portability, miniaturization, automatic, robustness, cost effectiveness and less time consuming method. The modern trend of miniaturization, detectors provide a high sensible for small detection of volume in the ranges from picogram to microgram in presence of low pollutant concentration [8]. In addition, they are versatile, affordable, accurate, reliable and compact in size. LEDs have the ability to be coupled with waveguides or optical fibers [9-13], to a wide variety of detectors such as, photodiode arrays [14-17], photomultiplier tubes [18-21], light dependent resistors [22-24], light emitting diodes [25-28], photodiodes [29-30], phototransistors [31-32], but the most common detector is used in LED based chemical sensors is the photodiode.

Color is used as an indicator for the detection of environmental pollutants (inorganic or organic compounds), both within and outside the laboratory. A color change with increasing in concentration of compound indicates the presence of that particular compound in any color assay of it. This is the easiest way to measure the color of a sample using with corresponding closet color visual chart. But, we can not manipulate the possible exact quantity of particular compounds in assay using color visual chart. The color of a sample assay, we are simply going to observe transmitted light through the composition of pollutant and it measure by the sensitive photodetector property. While, the color visual chart matches a color of sample, but the present optical sensor instrument gives a certain intensity signal for a particular pollutant composition [33]. To understand the quantitative analysis of environmental pollutants in its assay, Earlier, Many studied on environmental pollutants have been done using various types of sophisticated analytical instruments [34-39]. But, some of them have many drawbacks to develop the sensing devices with taking into account many qualities such as, simplification, speed, portability, miniaturization, cost effectiveness and less time consuming. Therefore, we are needed to develop a mini sensing technology that produced more possible accurate results with good comparable factors than sophisticated analytical instrument like UV-vis spectrophotometer.

An earlier effort is made by our groups and reported its application [40]. The present work is discussed here its advanced circuitry methodology of designed optical sensor using multiple laser LEDs with application for multifunctional analysis of the pollutants. The work will also provide more effective optical tool for detection of environmental pollutants and may also be most probably used in the field of biological, chemical and pharmaceutical industries. The basic optical sensor circuitry will helpful to design the sensor instrument for biologist, engineers, physicists, chemists and human resources developments. The present effort communicates with the computer using RS-232 ports that makes easier transformation of the data for a user directly from a peripheral device and gives a correct automatically information regarding with the analyte and also reducing the visual matching chart error and cost effective sophisticated analytical technology. Such an application provides simply instructions to develop a cost effective sensor with microcontroller-based data acquisition system circuitry designing with appropriate software tool to operate the optical sensor instrument that allow a display of the results on screen of computer via RS-232 communication.

2. Materials and Methods

The all components for circuitry designing such as, Light emitting diodes (LEDs; E1L31-3B0A2-02 LED, Toyoda Gosei Co., Ltd.)), amplifier (OP-07) and photodiodes (BPW21, Osram Semiconductors) used in this study were commercially available products from various manufactures National semiconductors, Hamamatsu, LED-Tech, Intel and Fairchild), were purchased R. S. components and solution Delhi, India.

Sodium hydroxide, Methanol, Hydroxyl ammonium hydrochloride, malathion, parathion and methyl parathion (80 % technical grade) were purchased from Bayer, India. All reagents used were of analytical grade.

3. Theoretical Model

In general, when a monochromatic intensity of laser LED falls on the pollutant sample, since some part of the intensity absorb by the analyte sample and the rest transmits through the pollutant sample, if the reflection is to be considered as negligible. Fig. 1 shows the functional block diagram for a portable data acquisition system (DAS) using discrete components. The transmit intensity collects on a detector terminals in the form of electrical energy.

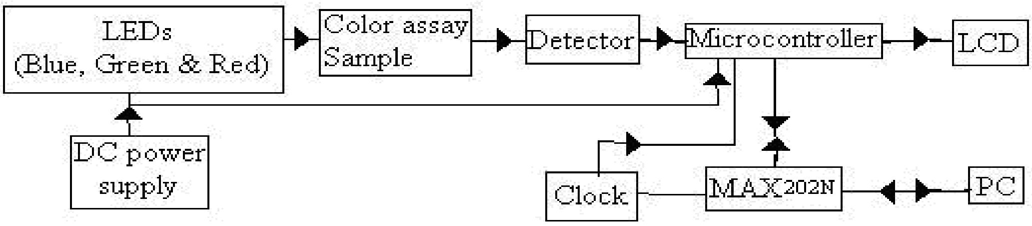

Fig. 1. A block diagram of Optical sensor Instrument.

The analytical instruments are used to provide the information about the composition of a pollutant sample and they are employed to obtain their quantitative/qualitative analysis in its formulations. The attenuation of a laser beam that passes through different concentrations of pollutant can be expressed by Beer-Lambert law [40-43] as

$$T = \frac{I_t}{I_0} = \exp \varepsilon * l * C , \qquad (1)$$

where T is the fraction of the incident light that is transmitted through different concentrations of pollutant, I_0 is the transmitted light intensity with the blank solution (i.e. without pollutants), I_t the transmitted light intensity with the various concentrations of pollutant, ε the molar extinction coefficient, *l* be the length of the path and C the concentration of pollutant in color species. Similarly, the transmitted portion of light beam through the sample, as a function of the quantity of pollutant in its colored species uniformly distributed on it and can be written in terms of voltage as

$$T = \frac{I_t}{I_0} = V_b * \exp(K_1 * m) \ , \qquad (2)$$

where V_b is the maximum output voltage on the photodiode terminal when blue color light from LED falls on the surface of photodiode (i.e. there is no colored species in the sample), K_1 is the proportionality constant and m is the mass per unit area of the substance, as the mass of a pollutant in solution is proportional to its concentration

$$T = \frac{I_t}{I_0} = V_b * (K * C) \tag{3}$$

or

$$V_t = m * C - b = -V \tag{4}$$

Therefore, linear correlation between the voltage (V) of the photodiode and the concentration (C) of pollutant is calculated, with b and m being the linear and the angular coefficients of the straight line, respectively. The relationship between theory of optical sensor and UV-vis spectrophotometry, if the reflection tends to nearest the zero value, can be written as

$$A = \frac{1}{T} = \frac{1}{-V} \tag{5}$$

For quantification of pollutant in water samples, the recoveries (R) of spiked additions of pollutant into water samples were treated with colorimetric reagents and the recoveries residue were also analysis with UV-vis spectrophotometry for validation of the results of optical sensor. The recoveries (R) can be calculated using mathematically equation as

$$R(\%) = \frac{T_s - T_r}{C} * 100 \ , \tag{6}$$

where T_s is the transmittance unit of standard concentration of spiked sample, T_r is the transmittance unit of spiked residue and C is the concentration of spiked sample in water samples. In the experimental procedure, the rate of reaction of pollutant (MP) with added reagents (like colorimetric reagents), was calculated using following relation

$$r = (1 - \frac{T_r}{T_s}) * 100 \ , \tag{7}$$

where T_s is the transmittance unit of a standard concentration of analyte and T_r is the residue analysis at certain time intervals (in sec) respectively.

3. Electronic Hardware Design

3.1. Circuitry of Light Source and Detector

The voltage generated by photodiode (BPW21, Osram Semiconductors) for different concentrations of environment pollutants was signal conditioned, then acquired and computed by a simple 8902051-24PI-microcontroller. The optimum operating parameters for better performance has been found and reported. The active phase was excited by means of a high-intensity blue laser light-emitting diode (E1L31-3B0A2-02 LED, Toyoda Gosei Co., Ltd.). The hardware design of a portable colorimetric sensor instrument is more complicated than just choosing the right IC to meet the required electrical performance. There are many tradeoffs here to be considered and described. The system includes power, analog, and digital circuitry. The power is derived from the batteries, with a power supply for a regulated output voltage. The power of LED is given directly a regulated ± 5V dc supply circuit with low rms values 0.5 %. This circuit contains an ON-OFF control switch to operate the LED's with a resistance. To save the laser LED for fuse, a resistance was connected, is shown in Fig. 2.

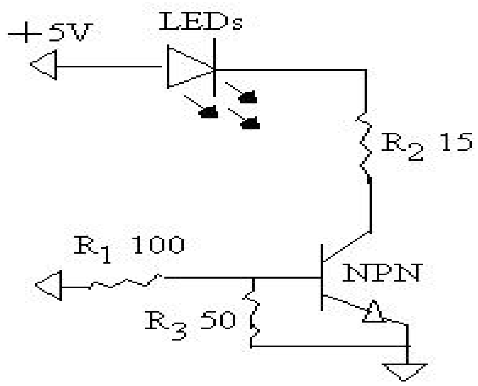

Fig. 2. A schematic of LED equivalent circuit.

The transmitted light from the object is detected with a photodetector. The produce photons from light source falls on the conducting surface of photodiode, at once the resistance becomes lower and a voltage is generated across the terminals. The generated output voltage on the photodiode terminals indicates the intensity of transmitted signals from the object, is shown in Fig. 3.

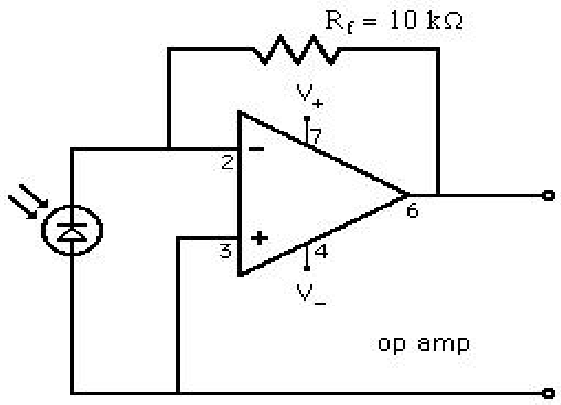

Fig. 3. A schematic of photodiode circuitry.

This identifies the exact amount of object in its assay. Further, these signals are amplified and then sent to ADC/DAS to collect and transfer the data conversion.

3.2. Signal Conditioning Circuit

The voltage generated on photodiode terminals depends on analyte concentration, area of light detecting chip inside the photodiode, and also on the color protocol used to circuitry designing of optical sensor instrument. Such arrangements also depend on angle between light source, position of sample holder and the detector. The output voltage on photodiode terminal is amplified using signal conditioning circuit as shown in Fig. 4. The photodiode output (voltage) is given to the input of the signal conditioning circuit. In the first stage, the output signal from the photodiode was given to a high accuracy instrumentation amplifier OP-07 to maintain the level of ±0-5V that is required for data acquisition system. In investigation of the observed voltage is noted for particular pollutant like methyl parathion at various concentrations level.

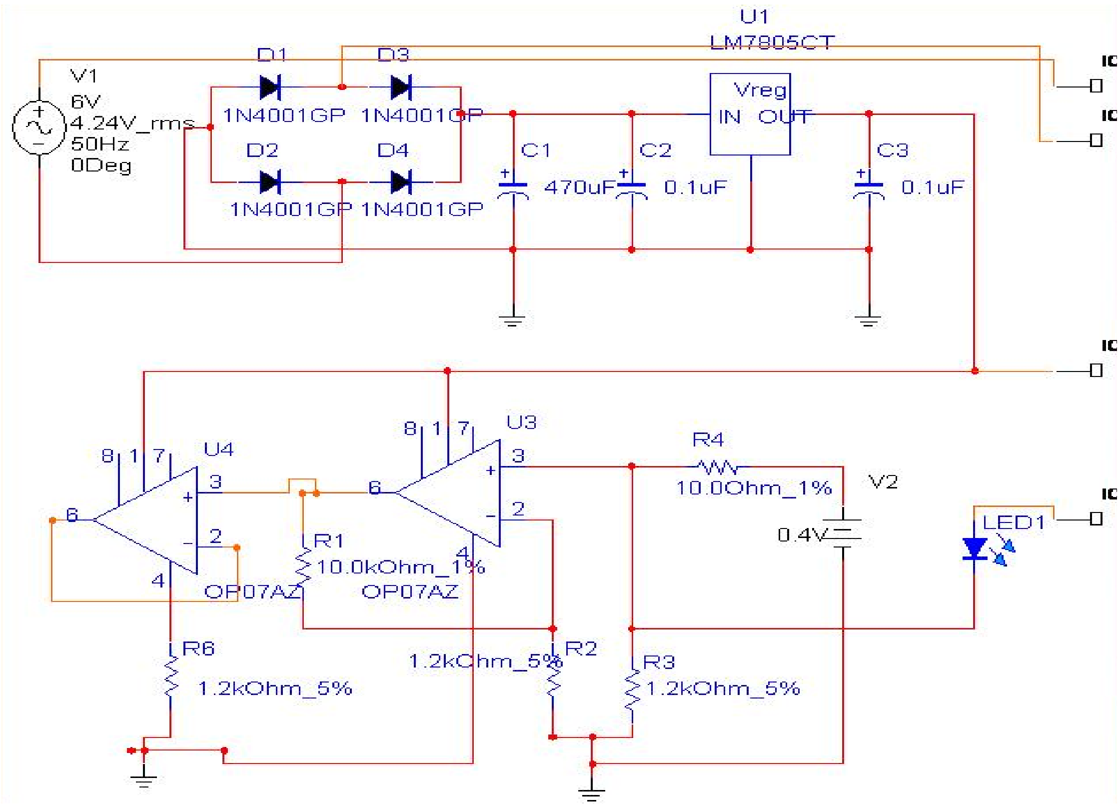

Fig. 4. Circuit diagram of amplifier circuit with power supply.

3.3. Analog to Digital Converter (ADC) and microcontroller based Data Acquisition System (DAS)

The output amplified analog signal is further transmit to the 8902051-24PI-microcontroller to conversion in an ADC-DAS. It operates with ±5V dc power supply. The conversion time of ADC is 100msec and clock frequency, 630 KHz is used. The required clock frequency was generated using LM-555 Timer, that operating in the range of 50 % duty cycle. The converted data from microcontroller is read from ADC and later it is displayed on LCD. 8902051-24PI microcontroller is an 8-bit and operated at 11.05 MHz clock frequency. It has 128 bytes of RAM and 64K ROM, two 16-bit Timer/counter, 32 I/O lines, 4 parallel I/O line, 6 interrupt ports and one programmable serial port. This technique of conversion is based on computation, and employed for unknown concentration samples of environmental pollutants and other chemicals.

The employed program is in the assembly language and generated Hex code into the EPROM of 8902051-24PI. Microcontroller was programmed to generate timer delay and used for another mode. The microcontroller sends start of conversion signal to ADC and later reads converted data, is shown in Fig. 5. These data stores in its internal section (RAM) in sequence. During the sample analysis, the data has been read at the end of 30 sec (because it is the steady state of optical sensor instrument). The sensor instrument communicates with the computer using RS-232 ports that makes much easier for a user to sent and receive the data directly from a peripheral device. It recommends trying the quick experiment results without wastage of time.

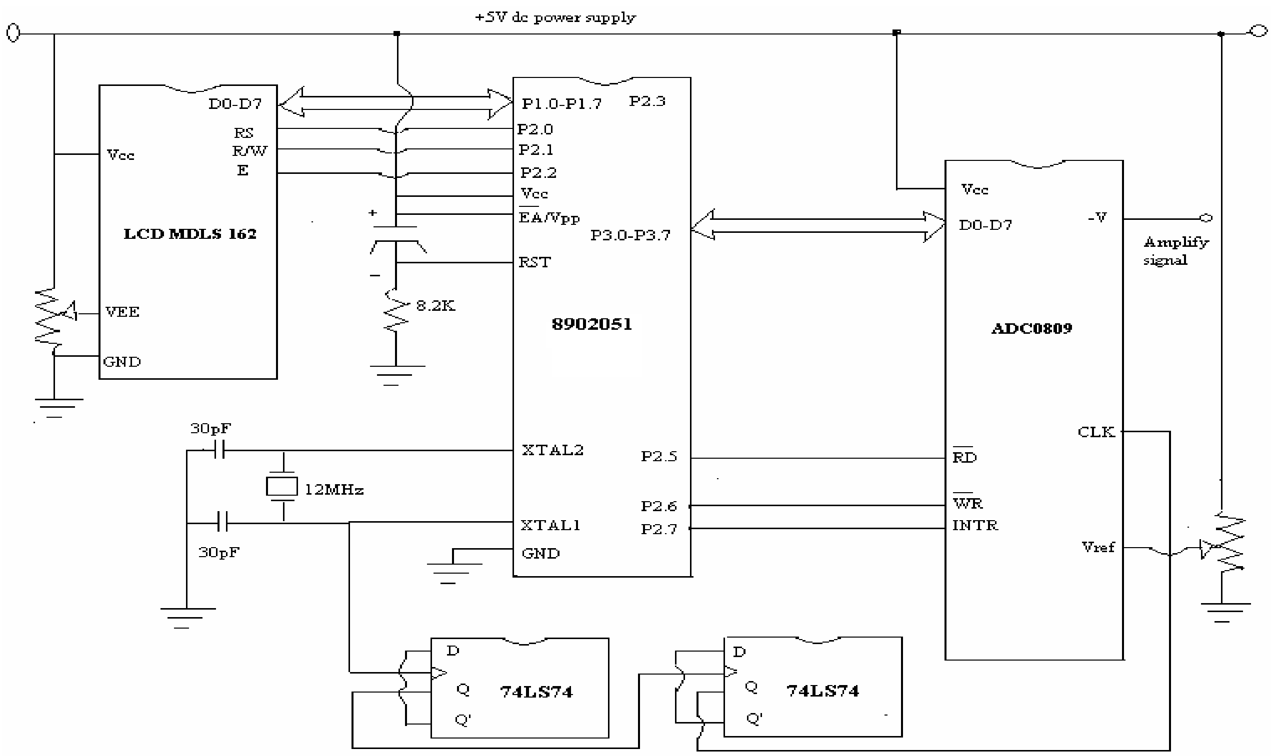

Fig. 5. Circuit diagram of ADC and microcontroller based DAS circuitry.

3.4. Algorithm and Coding to Read the Transmittance Data

The microcontroller is programmed with C code that will allow it to operate the LEDs and read the detector voltage. This code operates based on commands from the PC, which sent single character codes over the RS-232 line. The sensor instrument reads a value for a particular LED and sent it to the computer for display or further analysis. In general, a code is presented here to understand the mechanism of operating programme for a single LED (or single wavelength).

```
Unsigned char c;

C= getcUSART ( ); // get a single character off the USART line

If (c= = ‘r’)           // Turn blue LED on; read transmittance from the sample

{

            // Make sure red, green LEDs are off stage

             PORTDbits, RD1 = 0; // red LED in off stage

             PORTDbits, RD3 = 0; // green LED in off stage

            // Turn blue LED on
```

```
        PORTDbits, RD0 = 1;
        for (dloop=0; dloop<wait;dloop++) ; // wait a bit
        // Read Photodiode (BPW21) voltage
        while (BusyUSART ( ) ) ;
        convertADC ( ) ; // Perform ADC conversion
        while (BusyUSART ( ) ) ; wait for result
        blue = ReadADC ( ) ; // Get ADC Result
        PORTDbits, RD0 = 0; // Turn blue LED back off
        Data = blue >>4;
        putcUSART (data); // Put a single character on the USART line
        PIR1bits, RCIF = 0; // Reset the ISR flag.
}
```

Through this program the computer is able to send start date and time to the DAS or retrieve the acquired data for subsequent analysis. The DAS through the PC interrupt routine reads and decodes the command bytes sent by the PC, and performs the appropriate operation, as shown in Fig. 6. This shows the state of machine diagram for the measurement system. The system consists of four mode of operation like acquisition, storage, wait mode and PC mode. The microcontroller was programmed to be in a low power mode, except at specific times when data acquisition with the PC is in progress.

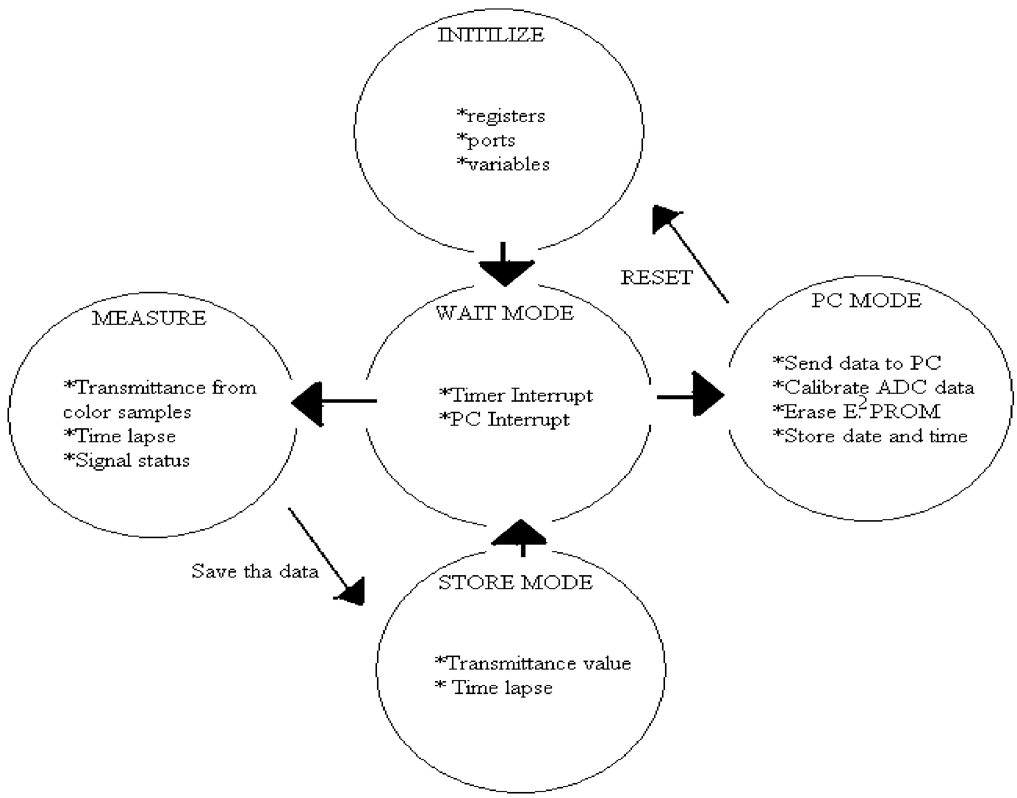

Fig. 6. The simple diagram to understand the operation of data acquisition system.

4. Results and Discussion

4.1. Quantification of MP

In order to test the reliability of the present methodology of designed sensor circuitry, it was applied to the determination of methyl parathion (MP) in water samples using certain steps of extraction process. The extraction of pollutant (MP) in water samples were reported by our group [42].

The quantification of MP in water samples can be calculated using equation (5), and the percentage recovery (R) can be calculated using equation (6). The recovery residue through colorimetric process were also compared with UV-vis spectrophotometry for validation of the results of optical sensor, is shown in Fig. 8. The control reading with spiked addition of MP into water samples were treated with colorimetric reagents and then noted the transmittance unit by designed optical sensor is shown in Fig. 7.

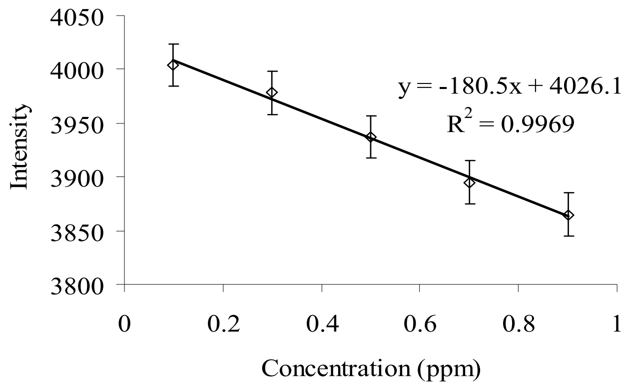

Fig. 7. The calibration graph of methyl parathion: concentration versus transmittance unit of samples.

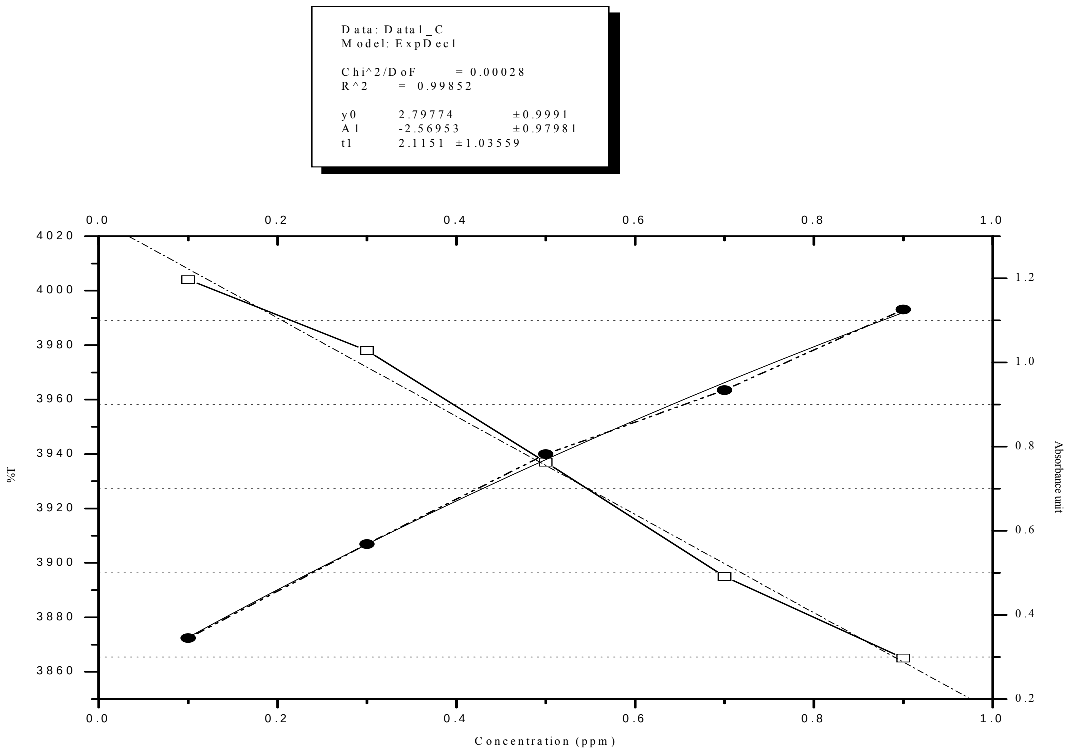

Fig. 8. A comparison results of MP with optical sensor Instrument and UV-vis spectrophotometer.

4.2. Study of Rate of Reaction of MP

For degradation analysis of methyl parathion, a UV peak band at 395 nm (E= 3.986 eV) gives the linear absorbance relationship with certain concentration of analyte is shown in Fig. 1 and Fig. 2 represents the higher degradability of methyl parathion 2 hrs approximately.

The data is considered to give enough precision and accuracy for the degradation study of methyl parathion. Here, it was observed that the rate of reaction increases as the amount of sensitizer increases and finally, the limit of analyte (MP) decreases, is shown in Fig. 9.

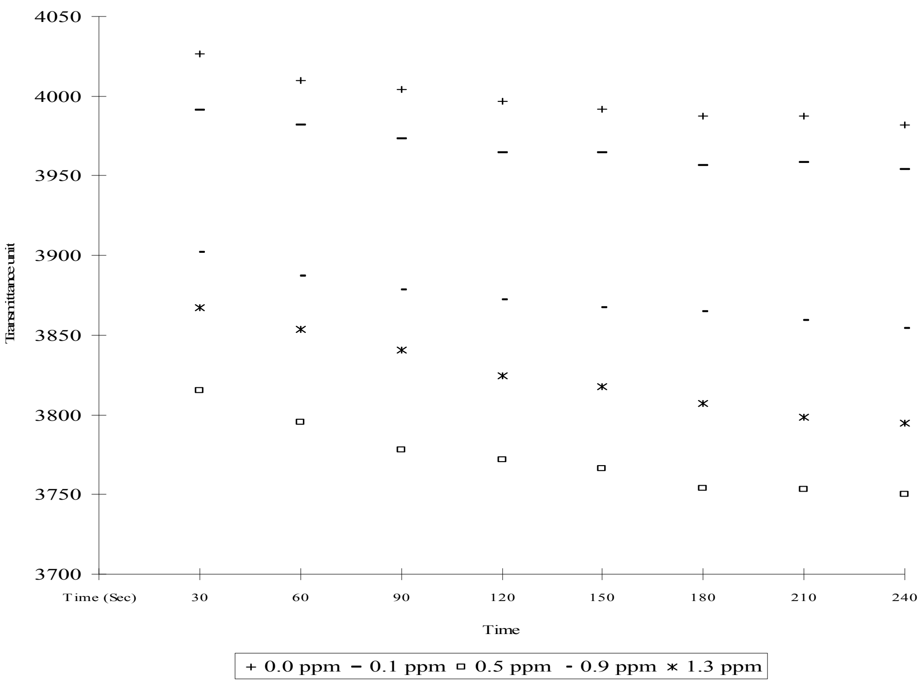

Fig. 9. Measurement of rate of reaction of MP by Optical Sensor.

4.3. Data Analysis

The performance of DAS results were calibrated with a Hitachi U-2800 UV-vis spectrophotometer results for analyzed of methyl parathion in its color assay. Measurements were taken in room temperature with accuracy. The average empirical first and second order quadratic calibration coefficients for methyl parathion respectively were obtained. So, the empirical function and data for optical sensor instrument as applied to methyl parathion monitoring (Fig. 7) are

Integration of data from zero:

i = 1 --> 5 (number of samples)

x = 0.1 --> 0.9

Area	Peak	Width	Height
3148.9	0.1	0.8	4004

Integration of derivative from zero

i = 1 --> 5

x = 0.1 --> 0.9 (concentration of methyl parathion in ppm)

Area	Peak	Width	Height
-139	0.5	0.8	-207.5

Linear Regression for Data

Y = A + B * X

Parameter	Value	Error
A	4026.05	4.65215
B	-180.5	8.09835

R^2	SD	N	P
-0.99699	5.12185	5	1.97738E^{-4}

Polynomial regression for data:

$Y = A + B_1X + B^2X^2$

Parameter	Value	Error
A	4023.31786	8.78142
B1	-164.42857	41.45713
B2	-16.07143	40.34292

R^2	SD	N	P
0.99444	6.03798	5	0.00556

In order to examine the accuracy, the DAS readings were recorded against UV-vis results. There is very close agreement with an error of ±5.4 % for methyl parathion. However, some errors occur due to prepare of color assay sample of methyl parathion relatively. This is mainly due to the difference in response time for color reagent with the analyte. The optical sensor instrument results for methyl parathion are shown in Fig. 7 and data is presented in Table 1**,** with their statistical parameters and comparing the results with UV-vis spectrophotometer are presented in Fig. 8.

The microcontroller was programmed to be in a low power mode, except at specific times when data acquisition with display on LCD. The operation of this data acquisition system is simple and no need to expertise in handling. The data acquisition system can be operating from a rechargeable battery so that the supply voltage, V_{cc} fluctuates with time and state of charge. As the analog-to digital conversion depends on this voltage. The work has been carried out to find the effects of variables and selection of suitable electronic components to design of circuitry for colorimetric sensor instrument. Its good response and optimized conditions with a program shows the modern concept of better performance for circuitry designing. The circuitry affects the results and thereby alters the response time, at higher concentration ranges of methyl parathion give the fluctuations in results with response of color reagent in its assay, and it also shifts potential and display nonlinear responses. The maximum linear response of optical sensor was observed at the temperature of 25±3°C for a particular range of pollutant (methyl parathion) detection range in its color assay and finally a dark colored product is obtained that shows the less linear response with the sensor instrument.

Table 1. Quantitative and statistical parameters for MP.

S. no.	Data and analytical parameters	Pollutant (MP)
1.	Concentration (in μg ml^{-1}); 0.1 0.3 0.5 0.7 0.9	Transmittance unit; 4004 3978 3937 3895 3865
2.	Line equation; y= m x + c	-180.5x + 4026.1
3.	Correlation coefficients (R^2)	0.9969
4.	Coefficient of Variation* (CV)	0.06
5.	Relative standard deviation (RSD)*	0.08

*(n=5 determinations)

5. Conclusion

A low cost handheld optical sensor with microcontroller based data acquisition system gives automatically measurements and records the data in its memory space. The designed optical sensor assembly is shown in Fig. 10. It has been programmed and applied for monitoring of environmental pollutants, in its environments, like methyl parathion in water sample. It has been successfully interfaced to a PC for initial setup of the system and for the data retrieval. The stored data are sent to a PC by a serial link and subjected to continuous data analysis. The quality of the data is good due to intrinsically small errors involved in digital data handling compared to conventional manual measurements. This errors ±4.5 % is acceptable for a lot of applications in visual applications. Moreover, the system is easily operated and does not require any programming expertise as compare to sophisticated instruments. Therefore, this procedure can be adopted for a routine checkup in quality control, academics, laboratory and field application purposes.

Acknowledgements

Authors express their gratitude to Department of Science & Technology, New Delhi, Government of India for financial support. Authors are also thankful to Dr. M. S. Gaur, Associate Professor, Hindustan College of Science & Technology, Mathura (India) for his scientific views. Authors are also thankful to Dr. S. S. Tiwari, Sensor Technology, Gwalior, India for his kind support.

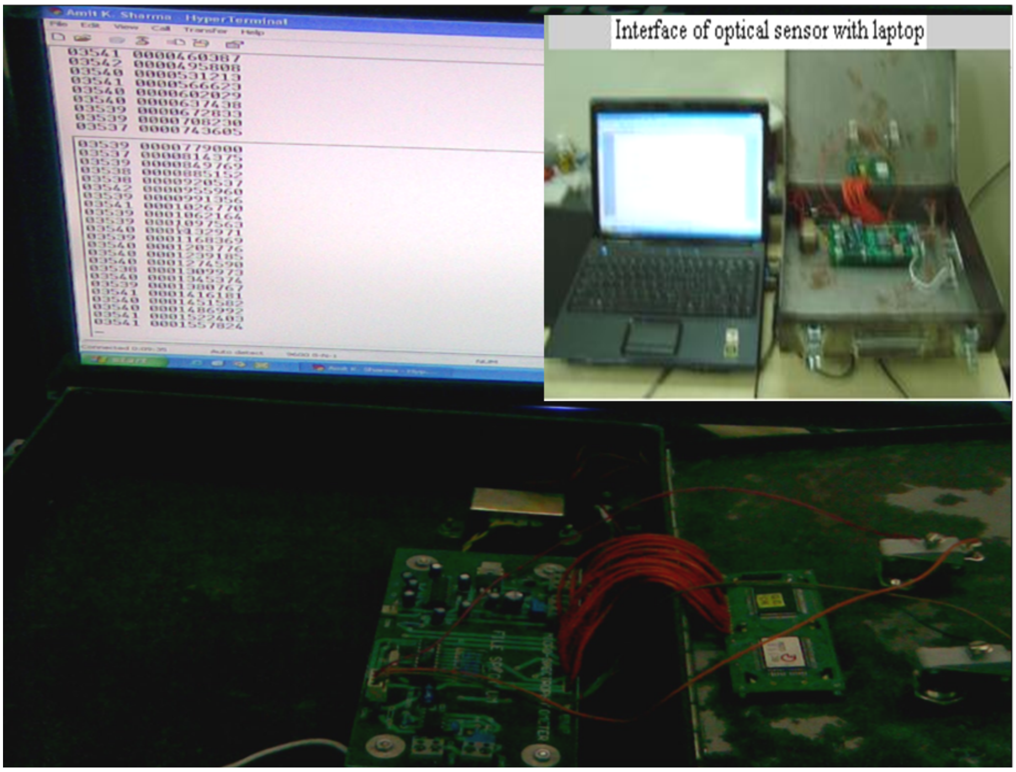

Fig. 10. Interface of designed optical sensor with computer.

References

[1]. R. Mukaro, X. F. Carelseand and L. Olumekor, First performance analysis of a silicon-cell microcontroller-based solar radiation monitoring system, *Solar Energy,* Vol. 63, 1998, pp. 313-321.

[2]. A. Namera, Y. Utsumi, Y. Mikio, M. Ohtani, T. Imamura and T. Kojima, Direct colorimetric method for determination of organophosphates in human urine, *Clinica Chimica Acta,* Vol. 291, 2000, pp. 9-18.

[3]. J. Kostovand and G. Rao, Low-cost optical instrumentation for biomedical measurements, *Rev. Sci. Instrum.,* Vol. 71, 2000, pp. 4361-4374.

[4]. D. Rawson and W. Gaisford, Biosensors monitor the environment, *Control Instrum.,* Vol. 22, 1990, pp. 63-64.

[5]. S. Franco, Design with operational Amplifiers and analog integrated circuits, *Tata McGraw-Hill*, 2000, pp. 60-91.

[6]. E. Lou, E. G. Durdle, V. J. Raso and D. L. Hill, A system for measuring pressures exerted by braces in the treatment of scoliosis, *IEEE Trans. Instrum. Meas.,* Vol. 43, 1994, pp. 661-664.

[7]. X. Huang, J. Liu, Z. Pi and Z. Yu, Qualitative and quantitative analysis of organophosphorus pesticides residues using temperature modulated SnO_2 gas sensor, *Talanta*, Vol. 64, 2004, pp. 538-545.

[8]. C. B. Boring and P. K. Dasgupta, An affordable high-performance optical absorbance detector for capillary systems, *Analytica Chimica Acta*, Vol. 342, 1997, pp. 123-132.

[9]. M. N. Taib and R. Narayanaswamy, Solid-state Instruments for optical fiber chemical sensors, *Analyst*, Vol. 120, 1995, pp. 1617-1625.

[10]. P. K. Dasgupta, Z. Genfa, S. K. poruthoor, S. Caldwell, S. Dong and S-Y. Liu, High sensitivity Gas sensors based on gas-permeable liquid core waveguides and long path absorbance detection, *Anal. Chem.,* Vol. 70, 1998, pp. 4661-4669.

[11]. K. Toda, K-I. Yoshioka, S-I. Li, J. Ohira and P. K. Dasgupta, Trace gas measurement with an integrated porous tube collector/long-path absorbance detector, *Anal. Chem.,* Vol. 75, 2003, pp. 4050-4056.

[12]. G. Samanta, C. B. Boring and P. K. Dasgupta, Continuous automated measurement of hexavalent chromium in airborne particulate matter, *Anal. Chem.,* Vol. 73, 2001, pp. 2034-2040.

[13]. S. Galanis and P. K. Dasgupta, Measurement of parts per million levels of potassium hydroxide in polyether polyol streams, *Anal. Chimica Acta*, Vol. 429, 2001, pp. 101-110.

[14].M. Sequeira, M. Bowden, E. Minogue and D. Diamond, Towards autonomous environmental monitoring systems, *Talanta*, Vol. 56, 2002, pp. 355-363.
[15].M. Bowden and D. Diamond, The determination of phosphorus in a Microfluidic manifold demonstrating long-term reagent lifetime and chemical stability utilizing a colorimetric method, *Sens. and Actua. B: Chemi.,* Vol. 9, 2003, pp. 170-174.
[16].B. J. White and H. J. Harmon, Optical solid-state detection of organophosphorus using organophosphorus hydrolase, *Biosens. and Bioelectro.,* Vol. 20, 2005, pp. 1977-1983.
[17].L. Ferrer, G. de Armas, M. Miro, J. M. Estela and V. A. Cerda, A multisyringeflow injection method for the automated determinations of sulfides in waters using a miniaturized optical fiber spectrophotometer, *Talanta*, Vol. 112, 2004, pp. 1119-1126.
[18].S-J. Chen, M. J. Chen and H-T. Chang, Light-emitting diode-based indirect fluorescence detection for simultaneous determination of anions and cations in capillary electrophoresis, *J. Chromatogr. A,* Vol. 1017, 2003, pp. 215-224.
[19].W. Schmidt, A high performance micro-dual-wavelength-spectrophotometer (MDWS). *J. Biochemical and Biophysical Methods*, Vol. 58, 2004, pp. 15-24.
[20].G. E. Collins, Q. Lu, N. Pereira and P. Wu, Long, pathlength, three-dimensional absorbance microchip, *Talanta*, Vol. 72, 2007, pp. 301-304.
[21].G. Deng and G. E. Collins, Nonaqueousbased microchip separation of toxic metal ions using 2-(5-bromo-2-pyridylazo)-5-(N-propyl-N-sulfopropylamino) phenol, *J. Chromatogr. A*, Vol. 989, 2003, pp. 311-316.
[22].F. A. A. Matias, M. M. D. C. Vila, and M. Tubino, A simple device for quantitative colorimetric diffuse reflectance measurements. *Sens. and Actua. B: Chemi.,* Vol. 88, 2003, pp. 60-66.
[23].K-T. Lau, R. Shepherd, D. Diamond and D. Diamond, Solid state pH sensor based on Light Emitting Diodes (LED) As detector platform, *Sensors*, Vol. 6, 2006, pp. 848-859.
[24].M. Tubino and R. L. de Souza, Determination of diclofenac in pharmaceutical preparations by diffuse reflectance photometry, *Talanta*, Vol. 68, 2006, pp. 776-780.
[25].M. O'Toole, K-T. Lau, R. Shepherd, C. Slater and D. Diamond, Determination of phosphate using a highly sensitive paired emitter-detector diode photometric detector, *Anal. Chimica Acta*, Vol. 597, 2007, pp. 290-294.
[26].K-T. Lau, W. S. Yerazunis, R. Shepherd and D. Diamond, Quantitative colorimetric analysis of dye mixtures using an optical photometer based on LED array, *Sens. and Actua. B: Chemi.,* Vol. 114, 2006, pp. 819-825.
[27].R. J. Berry, J. E. Harris and R. R. Williams, Light emitting diodes as sensors for colorimetric analyses, *Applied spectroscopy*, Vol. 51, 1997, pp. 1521-1524.
[28].M. Eiichi, I. Shin and A. Tsutomu, Using a light emitting diode as a high-speed, wavelength selective photodetector, *Review of Scientific Instruments*, Vol. 69, 1998, pp. 3751-3754.
[29].N. Gros, Spectrometer with microreaction chamber and tri-colour light emitting diode as a light source, *Talanta*, Vol. 62, 2004, pp. 143-150.
[30].A. Yamada, M. Sakuraba J. Murota, Integration of Si p-i-n diodes for light emitter and detector with optical waveguides, *Materials Science in Semiconductor Processing*, Vol. 8, 2004, pp. 435-438.
[31].M. A. Feres and B. F. Reis, A downsized flow setup based on multicommutation for the sequential photometric determination of iron(II)/iron(III) and nitrite/nitrate in surface water, *Talanta*, Vol. 68, 2005, pp. 422-428.
[32].A. Tan, J. Huang, L. Geng, J. Xu and X. Zhao, A multi-channel photometric detector for multicomponent analysis in flow injection analysis, *J. Automatic Chemistry*, Vol. 16, 1994, pp. 71-73.
[33].M. Schaper, P. Demes, E. Kiesswetter, M. Zupanic and A. Seeber, Colour vision and occupational toluene exposure: results of repeated examinations, *Toxicology Letters*, Vol. 151, 2004, pp. 193-202.
[34].A. W. Abu-Qare and M. B. Abou-Donia, Simultaneous determination of malathion, permethrin, DEET (*N*, *N*-diethyl-*m*-toluamide), and their metabolites in rat plasma and urine using high performance liquid chromatography, *J. Pharmaceutical and Biomedical Analysis,* Vol. 26, 2001, pp. 291-299.
[35].V. Seth, B. D. Banerjee R. S. Ahmed A. Bhattacharya and S. T. Pasha Alternations in immunoglobulins and cytokine levels in blood of malathion poisoning cases, *Indian J. Biochemistry and Biophysics*, Vol. 45, 2008, pp. 209-211.
[36].D. B. Barr, J. R. Barr, V. L. Maggio, R. D. Jr. Whitehead, M. A. Sadowski, Whyatt R. M. and L. L. Needham, A multianalyte method for the quantification of contemporary pesticides in human serum and plasma using high resolution mass spectrometry, *J. Chromatogr. B*, Vol. 778, 2002, pp. 99-111.
37]. S. G. Skoulika, C. A. Georgiou and M. G. Polissiou, Quantitative Determination of Fenthion in Pesticide Formulations by FT-Raman Spectroscopy, *Appl. Spectrosc.,* Vol. 53, 1999, pp. 1470-1474.

[38]. S. Armenta, G. Quintas, S. Garrigues and M. de la Guardia, Determination of cyromazine in pesticide commercial formulations by vibrational spectrometric procedures, *Anal. Chim. Acta*, Vol. 524, 2004, pp. 257-264.
[39]. A. M. Alak and T. Vo-Dinh, Surface-enhanced Raman spectrometry of organo phosphorus chemical agents, *Anal. Chem.*, Vol. 59, 1987, pp. 2149-2153.
[40]. A. K. Sharma, M. S. Gaur, P. Sharma, R. K. Tiwari and S. Bhadoria, Development of colorimetric Sensor Instrument for quantitative analysis of Methyl parathion, *Sensor Review*, Vol. 29, 2009, pp. 70-74.
[41]. A. V. Rossi, X. He and M. Tubino, A simple, portable and low cost device for a colorimetric spot test quantitative analysis, *Analy. Lett.*, Vol. 33, 2000, pp. 1885-1898.
[42]. M. S. Gaur, A. K. Sharma, P. Sharma, V. Mishra and S. Bhadoria, Spectrophotometric assessments of Methyl Parathion in water samples, *Canadian J. of Pure & Applied Sciences*, Vol. 2, 2008, pp. 581-587.
[43]. G. C. Windham, N-T. Holland, A. M. Osorio, S. Gettner, F. Reinisch, R. Haas and M. Smith, Genetic monitoring of malathion-exposed agricultural workers, *American Journal of Industrial Medicine*, Vol. 33, 1998, pp. 164 -174.

Guide for Contributors

Aims and Scope

Sensors & Transducers Journal (ISSN 1726-5479) provides an advanced forum for the science and technology of physical, chemical sensors and biosensors. It publishes state-of-the-art reviews, regular research and application specific papers, short notes, letters to Editor and sensors related books reviews as well as academic, practical and commercial information of interest to its readership. Because it is an open access, peer review international journal, papers rapidly published in *Sensors & Transducers Journal* will receive a very high publicity. The journal is published monthly as twelve issues per annual by International Frequency Association (IFSA). In additional, some special sponsored and conference issues published annually. *Sensors & Transducers Journal* is indexed and abstracted very quickly by Chemical Abstracts, IndexCopernicus Journals Master List, Open J-Gate, Google Scholar, etc.

Topics Covered

Contributions are invited on all aspects of research, development and application of the science and technology of sensors, transducers and sensor instrumentations. Topics include, but are not restricted to:

- Physical, chemical and biosensors;
- Digital, frequency, period, duty-cycle, time interval, PWM, pulse number output sensors and transducers;
- Theory, principles, effects, design, standardization and modeling;
- Smart sensors and systems;
- Sensor instrumentation;
- Virtual instruments;
- Sensors interfaces, buses and networks;
- Signal processing;
- Frequency (period, duty-cycle)-to-digital converters, ADC;
- Technologies and materials;
- Nanosensors;
- Microsystems;
- Applications.

Submission of papers

Articles should be written in English. Authors are invited to submit by e-mail editor@sensorsportal.com 8-14 pages article (including abstract, illustrations (color or grayscale), photos and references) in both: MS Word (doc) and Acrobat (pdf) formats. Detailed preparation instructions, paper example and template of manuscript are available from the journal's webpage: http://www.sensorsportal.com/HTML/DIGEST/Submition.htm Authors must follow the instructions strictly when submitting their manuscripts.

Advertising Information