ISSN 1726-5479

SENSORS & TRANSDUCERS

vol. 147
12/12

Sensor Market Trends

International Frequency Sensor Association Publishing

IFSA

Sensors & Transducers

Volume 147, Issue 12
December 2012

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).
Available in electronic and on CD.

Sensors & Transducers Journal

Contents

Volume 147
Issue 12
December 2012

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).

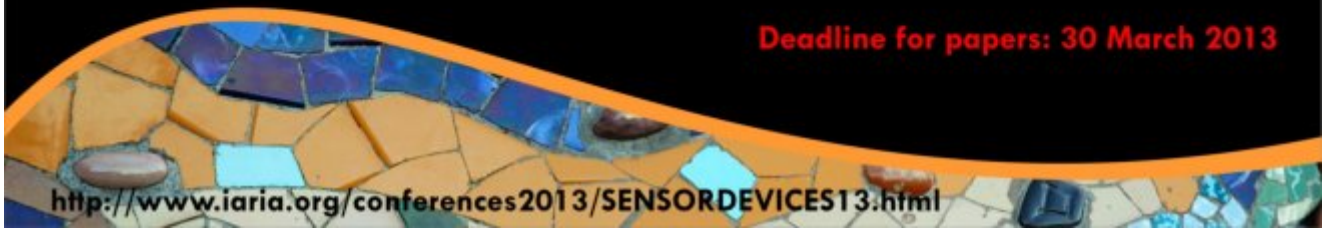
The Fourth International Conference on Sensor Device Technologies and Applications

SENSORDEVICES 2013

25 - 31 August 2013 - Barcelona, Spain

Tracks: Sensor devices - Ultrasonic and Piezosensors - Photonics - Infrared - Gas Sensors - Geosensors - Sensor device technologies - Sensors signal conditioning and interfacing circuits - Medical devices and sensors applications - Sensors domain-oriented devices, technologies, and applications - Sensor-based localization and tracking technologies - Sensors and Transducers for Non-Destructive Testing

Deadline for papers: 30 March 2013



http://www.iaria.org/conferences2013/SENSORDEVICES13.html

The Seventh International Conference on Sensor Technologies and Applications

Deadline for papers: 30 March 2013

SENSORCOMM 2013

25 - 31 August 2013 - Barcelona, Spain

Tracks: Architectures, protocols and algorithms of sensor networks - Energy, management and control of sensor networks - Resource allocation, services, QoS and fault tolerance in sensor networks - Performance, simulation and modelling of sensor networks - Security and monitoring of sensor networks - Sensor circuits and sensor devices - Radio issues in wireless sensor networks - Software, applications and programming of sensor networks - Data allocation and information in sensor networks - Deployments and implementations of sensor networks - Under water sensors and systems - Energy optimization in wireless sensor networks

http://www.iaria.org/conferences2013/SENSORCOMM13.html

The Sixth International Conference on Advances in Circuits, Electronics and Micro-electronics

CENICS 2013

25 - 31 August 2013 - Barcelona, Spain

Deadline for papers: 30 March 2013

Tracks: Semiconductors and applications - Design, models and languages - Signal processing circuits - Arithmetic computational circuits - Microelectronics - Electronics technologies - Special circuits - Consumer electronics - Application-oriented electronics

http://www.iaria.org/conferences2013/CENICS13.html

Sensors & Transducers Journal, Vol. 147, Issue 12, December 2012, pp. 36-44

www.sensorsportal.com

Sensors & Transducers

ISSN 1726-5479

http://www.sensorsportal.com

Detecting Water Content in Hydrocarbon Emulsion Using Acoustic and Ultrasonic Detectors

Rateb ISSA, Ibrahim AL-ABBAS and Hussein SARHAN
Balqa Applied University, Faculty of Engineering Technology, Mechatronics Engineering Department,
P.O. Box 15008, 11134, Amman, Jordan
E-mail: ratebissa@yahoo.com

Received: 16 August 2012 /Accepted: 18 December 2012 /Published: 31 December 2012

Abstract: In this paper, the acoustic approach and the ultrasonic approach are designed and investigated to be used for detecting the water content in hydrocarbon emulsions. The acoustic approach based on creating a standing wave in chamber contains a sample under test. The frequency of acquired signal by a microphone is measured and entered to PC using a sound card. In the ultrasonic approach a combination of ultrasonic transmitter/receiver is utilized. The amplitude of reflected signal is measured. The signal processing is realized using LabView signal processing tool for both approaches. The acoustic and ultrasonic approaches were tested and verified and the experimental results show their acceptability for common industrial applications, with a maximum percentage nonlinearity of ±0.95 %. *Copyright © 2012 IFSA.*

Keywords: Acoustic approach, Standing wave, Ultrasonic approach, LabView.

1. Introduction

Quality control is one of the main problems in economics and industry. Leading hand to solve the problem of quality improvement in oil production and processing is based on analytical monitoring. Analytical monitoring is achieved by the help of different types of physical-chemical analyzers and quality index raw material and end product. Taking into account the demand of oil products in industry which affects on the performances of plant, machines and their efficiency; the problem of quality control plays a great role in vital activity. This determined exacting requirements to monitor the quality of oil production and processing.

One of the valuable indexes in oil monitoring is detecting the content of water in oil and oil products. In this case water in oil appears as hydrocarbon emulsion. Monitoring of such parameter is realized with laboratory instrumentation techniques which include method of analysis and laboratory analyzer. The aim of this work is to develop an acoustic/ultrasonic analyzer which can be used to determine the content of water in oil (kerosene is taken as a sample under test). Two different studies are presented. The first study aims to investigate the possibility of detecting the content of water in hydrocarbon emulsion using ultrasonic waves. It was found that the reflected ultrasonic wave is a function of water content in kerosene. The second study aims to build a low-cost computer based analyzer in which standing wave is created in a medium. It was found that the measured frequency of created standing wave is a function of water content in kerosene.

2. Literature Review

Analytical monitoring of oil product as raw material or in final stages is an important issue in several fields of industry.

Small contents of water in oil which appears as hydrocarbon emulsion [1] may affect on performance of operated system which can be a vehicle or a turbine system [2]. Besides, it also can be very dangerous, generating pollution causes financial losses to the industry. For those reasons, it is essential to have a fast and efficient detection system which can be used to detect the content of water in oil or oil products.

Various techniques are available to detect water content in hydrocarbons. Technologies that are restricted to laboratory use may provide the most valuable data, but these are not commonly used in fieldwork, where fast reading times are critical for the management of an effective processing. Water content can be detected using special pastes which change their color on contact with water [3].

Several analytical methods have been developed to determine the water content in organic materials. The classic method for the determination of water is the Karl Fischer method [4]. The method is based on variation of color of the sample under test when it contains water.

A substance which is chemically inert to oil product but reacts to water is also used to detect the water contaminate in oil product [5]. Contacting the substance to oil contains water causes a gas to be produced, and then the amount of gas is measured. The main disadvantages of these works are destructivity, complexity and large time delay amounting to 3 minutes.

Gas chromatography and mass spectrometers are good analytical techniques which can be used to make qualitative and quantitative measurement including detecting the presence of water in oil. These techniques are usually used in laboratory to provide off line measurements of samples.

Acoustic methods of detection are also utilized to measure and detect many physical phenomena. Gas chromatography detectors based on measuring the velocity of sound in resonance tube [6] are good examples where acoustic measurement is applied.

Acoustic field was also combined with thermo effect to build a simple analyzer [7] which was used to measure the concentration of water content in kerosene. The signal obtained by this analyzer was presented as a “chromatogram”.

The literature review of existing measurement detectors or analyzers which are used to make qualitative and quantitative test of oil product shows that this issue is still developing. This explains why research and development in this field is a viable continuous process. Determining water

contamination in oil can be realized using different types of analyzers and detectors. The work described in this paper presents the possibility of using an acoustic/ ultrasonic measurement in order to measure and detect the presence of water in oil product (kerosene is taken as a sample under test).

3. Experiment Design

3.1. Approaches Used in Experiment

The present work solves the problem of detection of water contaminate in hydrocarbon emulsions. Kerosene is taken as a sample under test. Two approaches are applied to solve the mentioned above problem:
- Acoustic approach based on generation of a standing wave within a tested medium;
- Ultrasonic approach, where the reflected ultrasonic wave is measured.

3.1.1. Acoustic Approach

In this approach the free mode of standing wave generation is applied. The standing wave is created in the chamber filled by a sample under test. The standing wave may be created using the principle of acoustic resonance, which is usually realized by using a speaker- microphone combination [8]. The sound card of PC is utilized in order to create an acoustic standing wave between the (AT) and (AR) which is transmitted through the sample under test. As a result, the speed of transmitted acoustic signal varies depending on the type of the medium filled in the chamber. This variation of speed is usually characterized by the frequency of created acoustic standing wave. The frequency of acoustic wave is measured by sound card of PC and LabVIEW software.

3.1.2. Ultrasonic Approach

In this approach a classical ultrasonic ranger consisting of transmitter and receiver in the same side is used. The transmitter sends an ultrasonic signal to the medium, which may be absorbed, propagated, scattered or reflected. The reflected signal is received by ultrasonic receiver estimated by measuring the amplitude of reflected signal using PICOSCOPE and Lab View software.

3.2. Experimental Setup

3.2.1. The Acoustic Approach Experimental Setup

The acoustic approach experimental setup and LabVIEW block diagram are shown in Fig. 1.

The combination of speaker – microphone allows to generate an acoustic standing wave with a frequency value dependent on distance between the speaker and microphone and the medium. The signal from the microphone is fed to the sound card input and processed by LabView program shown in Fig. 2.

In this block diagram the MIC VI is used to acquire signal the microphone input. Then the Tone Measurements VI is utilized to measure the frequency of the signal. The measured frequency is introduced to band pass filter in order to remove higher order harmonics of the signal and keeping only the first harmonic, smoothing filter VI is used to smooth and reduce disturbance in the measured frequency and displayed on indicator.

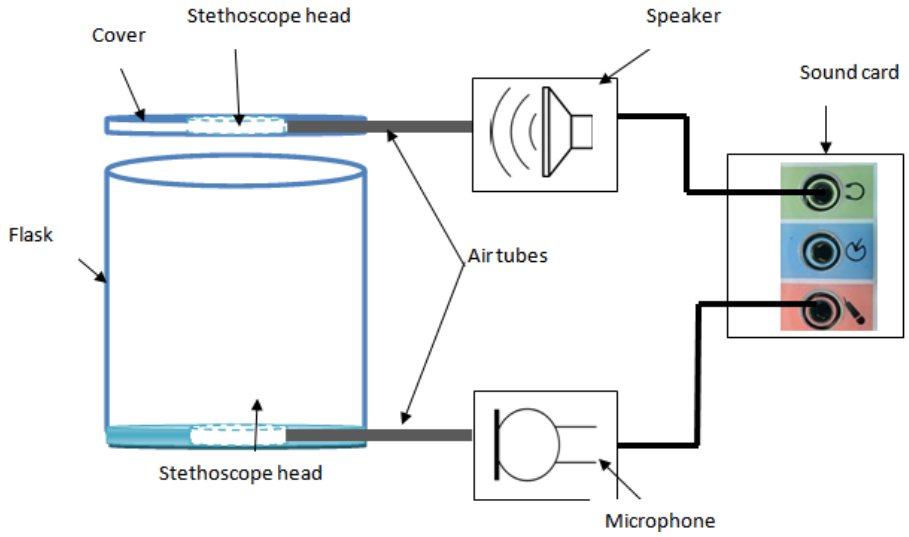


Fig. 1. Acoustic approach experimental setup.

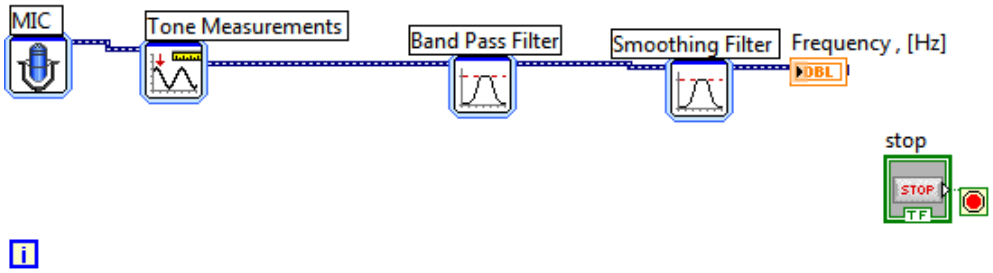


Fig. 2. The acoustic analyzer LabView program.

3.2.2. The Ultrasonic Approach Experimental Setup

The ultrasonic approach experimental setup is shown in Fig. 3.

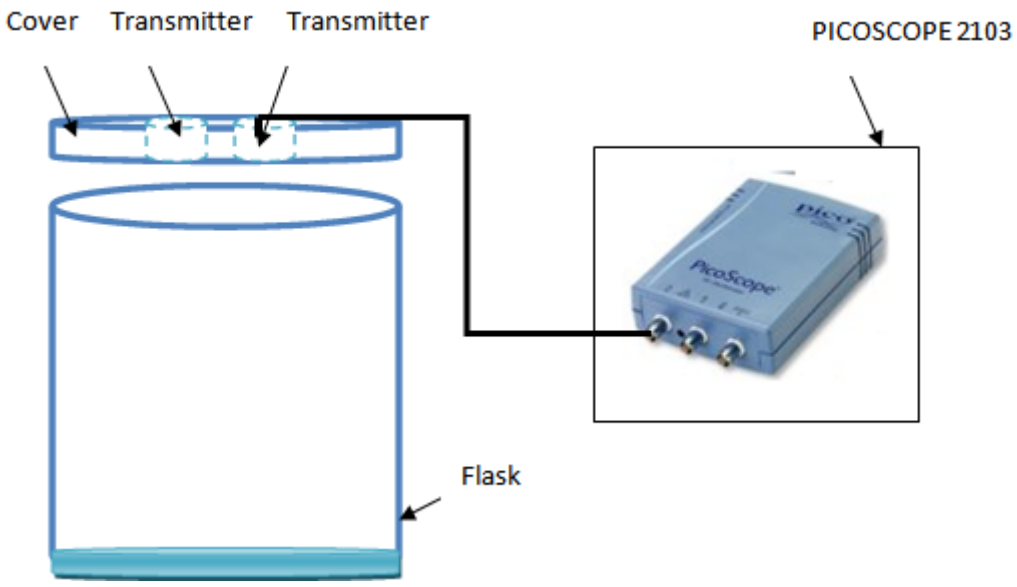


Fig. 3. Ultrasonic approach experimental setup.

It consists of plastic flask which is filled by the sample and classical ultrasonic ranger which is placed on the inner part of the cover. The ranger consists of ultrasonic transmitter, receiver and corresponding conditioning circuit. The ultrasonic system is powered by +5 V from USB of PC and the output of receiver is connected to oscilloscope type PICOSCOPE 2003. The signal processing and analyses are realized by the help of LabView 2010 software which is shown in Fig. 4.

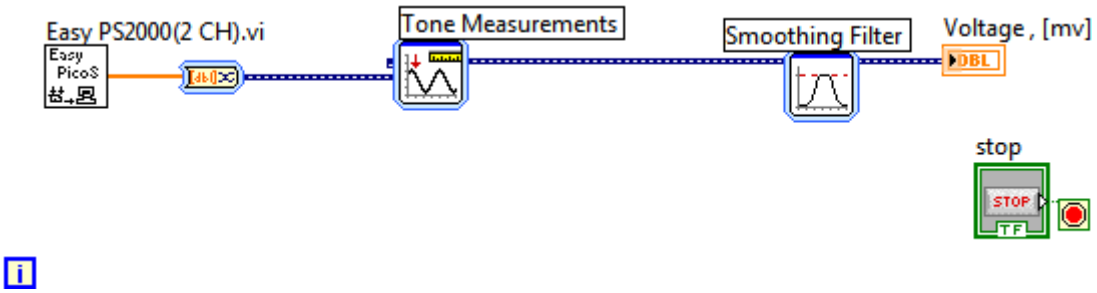


Fig.4. The LabVIEW program for Ultrasonic analyzer.

3.3. Principle of Operation and Mathematical Model

3.3.1. Principle of Operation of Experimental Setup Based on Acoustic Approach

When the flask is filled by pure kerosene, the velocity of sound in the medium has an exact value equal to the speed of sound in kerosene and then the frequency of generated standing wave is given by:

$$f_K = \frac{C_K}{L_K}, \tag{1}$$

where C_K is the speed of sound in kerosene and L_K is the distance between the two heads of oscilloscope when the whole flask is filled by kerosene.

$$C_K = \sqrt{\frac{E_K}{\rho_K}}, \tag{2}$$

where E_K is the bulk modulus of kerosene and ρ_K is the density of kerosene.

If the kerosene contains small amount of water the average speed of sound is:

$$\bar{C} = C_W + C_K, \tag{3}$$

where C_W is the speed of sound in water and given by:

$$C_W = \sqrt{\frac{E_W}{\rho_W}}, \tag{4}$$

where E_W is the bulk modulus of water and ρ_W is the density of water.

The corresponding average frequency of generated standing wave is given by:

$$\bar{f} = \frac{\bar{C}}{\bar{L}}, \tag{5}$$

where: $\bar{L} = L_W + L_K$ and L_W is the path which is traveled by standing wave.

3.3.2. Principle of Operation of Experimental Setup Based on Ultrasonic Approach

In this approach the generated ultrasonic wave passes the medium. Part of this wave is absorbed or scattered or reflected. The signals from the ultrasonic generator and the ultrasonic receiver are recorded on the digital oscilloscope.

In fact the measurement can be considered as measuring the level of liquid in container. So to obtain the mathematical model, in this approach we use the level measurement relationship presented in [8] for measuring the level using ultrasonic approach when the container is filled by pure kerosene.

The kerosene level h_K is given by:

$$h_K = \frac{C_K}{2} t_K, \tag{6}$$

where t_K is the round trip time of transmitted wave in kerosene.

If the kerosene contains a small amount of water, the level h can be presented by:

$$h = h_K + h_W, \tag{7}$$

where h_W is the level of water and given by:

$$h_W = \frac{C_W}{2} t_W, \tag{8}$$

where t_K is the round trip time of transmitted wave in water.

Considering equations (6) and (8) equation (7) can be rewritten as:

$$h = \frac{C_K}{2} t_K + \frac{C_W}{2} t_W \tag{9}$$

4. Experimental Results

In order to evaluate the proposed techniques and to investigate the relationship between composition and the output signal for both approaches, multiple water-in-emulsion percentages (A chamber with a volume of 1000 mL is filled by a sample under test) are tested to estimate the generated frequencies in acoustic approach and produced voltages in ultrasonic approach. To represent the data, the method of

data regression is used by utilizing Matlab curve Fitting Toolbox. A linear equation is used to fit the regression model for both techniques.

4.1. Acoustic Based Approach Experimental Result

The acoustic based approach experimental results are shown in Table 1 and Fig. 5.

Table 1. Acoustic based approach experimental results.

Water content, [mL]	10	20	30	40	50	60	70	80	90	100
F, [Hz]	1500	1275	1200	993	905	750	485	445	320	140

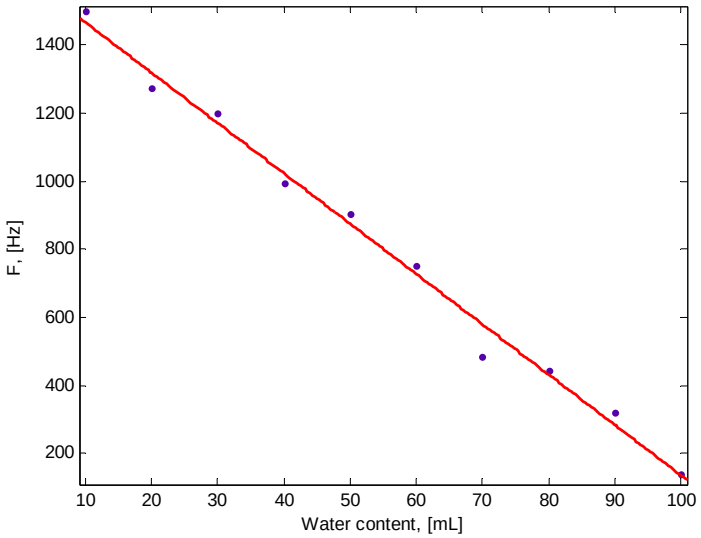


Fig. 5. The relationship between the water content and frequency.

In this approach, a microphone- speaker combination is utilized to create standing wave in a chamber made of glass (1000 mL) and filled by a sample under test. The output signal of microphone is connected to the sound card of PC and the signal processing was realized by LabView software. In order to measure frequency of the signal acquired by microphone by LabView the Tone Measurements VI bock used. The measured signal is then filtered and displayed by indicator.

4.2. Ultrasonic Based Approach Experimental Result

The ultrasonic based approach experimental results are shown in Table 2 and Fig. 6.

Table 2. Ultrasonic based approach experimental results.

Water content, [mL]	10	20	30	40	50	60	70	80	90	100
Voltage, [mV]	380	330	310	280	240	215	195	175	120	90

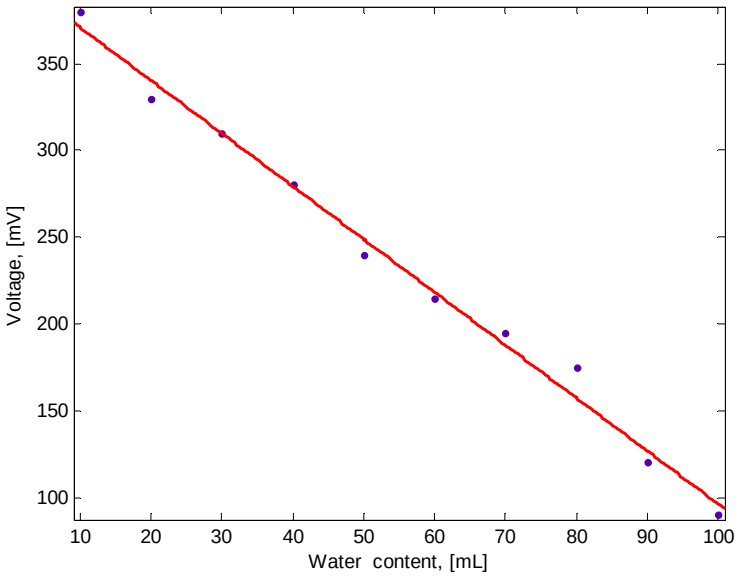


Fig. 6. The relationship between the water content and voltage.

In this approach, the transmitted ultrasonic wave in glass chamber (1000 mL) is reflected and introduced into ultrasonic receiver. The output signal of ultrasonic receiver is entered into DAQ device, which allows processing the acquired signal by PC under LabVIEW environment. In order to measure the amplitude of reflected ultrasonic signal acquired by receiver, the Tone Measurements VI bock is used. The measured signal is then filtered and displayed by indicator.

5. Conclusions

Detection of water content in hydrocarbon emulsion is proposed using two different approaches based on measurement of the sound propagation in a media. The two demonstrated approaches allow measuring the water content in hydrocarbon emulsion. The experimental results revealed that the generated acoustic signal (frequency in acoustic approach and voltage in ultrasonic one) is related to the properties of the tested hydrocarbon emulsion. Concerning the transducer nonlinearity error by using the experimental results and regression model, it was found that the maximum nonlinearity (to F.S.D) is equal to ±0.95 %. .

References

[1]. R. Cardenas, R. Pena, J. R. S. Ruiz, S. Villegas, S. Serpa, J. Nahuelquin, Detection of oil in water and water in oil emulsions inside a phase separator washing tank, in *Proceedings of the 16th IEEE Instrumentation and Measurement Technology Conference* (*IMTC' 99)*, pp. 332 – 337.

[2]. Alexander, John D., Reed, Philip W., Sonic measurement of flow rate and water content of oil-water streams, *Patent* No. 4080837 (USA).

[3]. M. Pramanik, G. Ku, C. H. Li and L. H. Wang, Design and evaluation of a novel breast cancer detection system combining both thermo-acoustic (TA) and photo-acoustic (PA) tomography, *Med. Phys.*, 35, 6, 2008, pp. 2218–2223.

[4]. G. S. Kino and R. G. Stearns, Acoustic wave generation by thermal excitation of small regions, *Appl. Phys. Lett.*, 47, 9, 1985, pp. 926-928.

[5]. M. Iqbal, O. Morel and F. Meriaudeau, Survey of outdoor water detection, in *Proc. of the 5th International Conference on Information & Communication Technology and Systems*, (ICTS' 2009), Indonesia.

[6]. Tariq Younes, Acoustic detector for gas chromatography, *Patent* No. 33233, Russian Federation, 2003.

[7]. Tariq M. Younes, Mohammad A. Al-Khedher & Mohammad A. K. Alia, Thermoacoustic analyzer for

water content detection in hydrocarbon emulsion, *International Journal of Research and Reviews in Applied Sciences*, Vol. 10, Issue 1, 2012.

[8]. Anil Kumar Gupta and R. K. Sharma, A New Method for Estimation of Automobile Fuel Adulteration, *Air Pollution*, 2010.

Sensors & Transducers Journal

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 of it is a peer reviewed international journal, papers rapidly published in *Sensors & Transducers Journal* will receive a very high publicity. The journal is published monthly as twelve issues per year by International Frequency Sensor 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. Since 2011 the journal is covered and indexed (including a Scopus, Embase, Engineering Village and Reaxys) in Elsevier products.

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

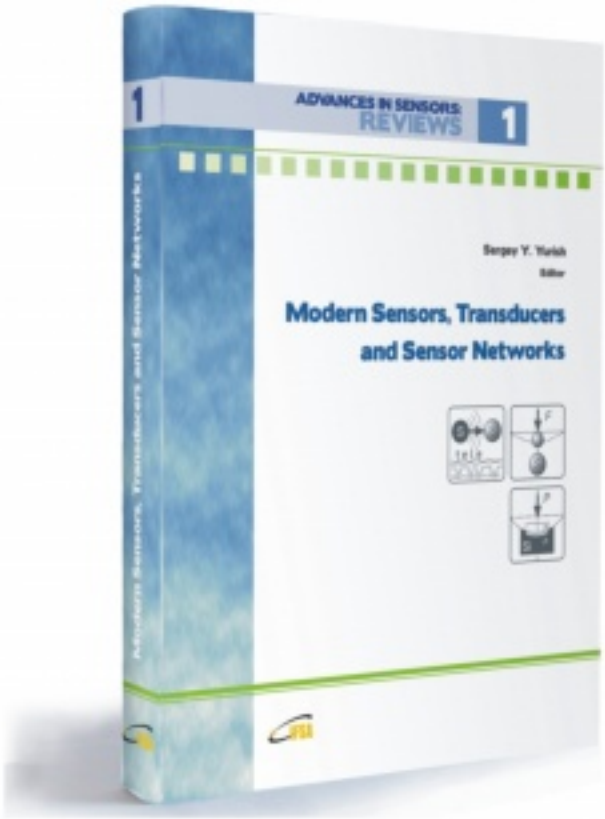
Advertising orders and enquires may be sent to sales@sensorsportal.com Please download also our media kit: http://www.sensorsportal.com/DOWNLOADS/Media_Kit_2012.pdf

International Frequency Sensor Association Publishing

ADVANCES IN SENSORS: REVIEWS 1

Sergey Y. Yurish
Editor

Modern Sensors, Transducers and Sensor Networks



Modern Sensors, Transducers and Sensor Networks is the first book from the Advances in Sensors: Reviews book Series contains dozen collected sensor related state-of-the-art reviews written by 31 internationally recognized experts from academia and industry.

Built upon the series Advances in Sensors: Reviews - a premier sensor review source, the *Modern Sensors, Transducers and Sensor Networks* presents an overview of highlights in the field. Coverage includes current developments in sensing nanomaterials, technologies, MEMS sensor design, synthesis, modeling and applications of sensors, transducers and wireless sensor networks, signal detection and advanced signal processing, as well as new sensing principles and methods of measurements.

Modern Sensors, Transducers and Sensor Networks is intended for anyone who wants to cover a comprehensive range of topics in the field of sensors paradigms and developments. It provides guidance for technology solution developers from academia, research institutions, and industry, providing them with a broader perspective of sensor science and industry.

Order online:
http://sensorsportal.com/HTML/BOOKSTORE/Advance_in_Sensors.htm

www.sensorsportal.com