

ISSN 1726-5479

SENSORS & TRANSDUCERS

1 vol. 124
/11



Sensor Instrumentation, DAQ and Virtual Instruments

International Frequency Sensor Association Publishing





Sensors & Transducers

Volume 124, Issue 1,
January 2011

www.sensorsportal.com

ISSN 1726-5479

Editors-in-Chief: professor Sergey Y. Yurish, tel.: +34 696067716, fax: +34 93 4011989, e-mail: editor@sensorsportal.com

Editors for Western Europe

Meijer, Gerard C.M., Delft University of Technology, The Netherlands
Ferrari, Vittorio, Università di Brescia, Italy

Editor South America

Costa-Felix, Rodrigo, Inmetro, Brazil

Editor for Eastern Europe

Sachenko, Anatoly, Ternopil State Economic University, Ukraine

Editors for North America

Datskos, Panos G., Oak Ridge National Laboratory, USA
Fabien, J. Josse, Marquette University, USA
Katz, Evgeny, Clarkson University, USA

Editor for Asia

Ohyama, Shinji, Tokyo Institute of Technology, Japan

Editor for Asia-Pacific

Mukhopadhyay, Subhas, Massey University, New Zealand

Editorial Advisory Board

Abdul Rahim, Ruzairi, Universiti Teknologi, Malaysia
Ahmad, Mohd Noor, Northern University of Engineering, Malaysia
Annamalai, Karthigeyan, National Institute of Advanced Industrial Science and Technology, Japan
Arcega, Francisco, University of Zaragoza, Spain
Arguel, Philippe, CNRS, France
Ahn, Jae-Pyoung, Korea Institute of Science and Technology, Korea
Arndt, Michael, Robert Bosch GmbH, Germany
Ascoli, Giorgio, George Mason University, USA
Atalay, Selcuk, Inonu University, Turkey
Atghiaee, Ahmad, University of Tehran, Iran
Augutis, Vyantas, Kaunas University of Technology, Lithuania
Avachit, Patil Lalchand, North Maharashtra University, India
Ayeshe, Aladdin, De Montfort University, UK
Bahreyni, Behraad, University of Manitoba, Canada
Baliga, Shankar, B., General Motors Transnational, USA
Baoxian, Ye, Zhengzhou University, China
Barford, Lee, Agilent Laboratories, USA
Barlingay, Ravindra, RF Arrays Systems, India
Basu, Sukumar, Jadavpur University, India
Beck, Stephen, University of Sheffield, UK
Ben Bouzid, Sihem, Institut National de Recherche Scientifique, Tunisia
Benachiba, Chellali, Université de Bechar, Algeria
Binnie, T. David, Napier University, UK
Bischoff, Gerlinde, Inst. Analytical Chemistry, Germany
Bodas, Dhananjay, IMTEK, Germany
Borges Carval, Nuno, Universidade de Aveiro, Portugal
Bousbia-Salah, Mounir, University of Annaba, Algeria
Bouvet, Marcel, CNRS – UPMC, France
Brudzewski, Kazimierz, Warsaw University of Technology, Poland
Cai, Chenxin, Nanjing Normal University, China
Cai, Qingyun, Hunan University, China
Campanella, Luigi, University La Sapienza, Italy
Carvalho, Vitor, Minho University, Portugal
Cecelja, Franjo, Brunel University, London, UK
Cerde Belmonte, Judith, Imperial College London, UK
Chakrabarty, Chandan Kumar, Universiti Tenaga Nasional, Malaysia
Chakravorty, Dipankar, Association for the Cultivation of Science, India
Changhai, Ru, Harbin Engineering University, China
Chaudhari, Gajanan, Shri Shivaji Science College, India
Chavali, Murthy, N.I. Center for Higher Education, (N.I. University), India
Chen, Jiming, Zhejiang University, China
Chen, Rongshun, National Tsing Hua University, Taiwan
Cheng, Kuo-Sheng, National Cheng Kung University, Taiwan
Chiang, Jeffrey (Cheng-Ta), Industrial Technol. Research Institute, Taiwan
Chiriac, Horia, National Institute of Research and Development, Romania
Chowdhuri, Arijit, University of Delhi, India
Chung, Wen-Yaw, Chung Yuan Christian University, Taiwan
Corres, Jesus, Universidad Publica de Navarra, Spain
Cortes, Camilo A., Universidad Nacional de Colombia, Colombia
Courtois, Christian, Université de Valenciennes, France
Cusano, Andrea, University of Sannio, Italy
D'Amico, Arnaldo, Università di Tor Vergata, Italy
De Stefano, Luca, Institute for Microelectronics and Microsystem, Italy
Deshmukh, Kiran, Shri Shivaji Mahavidyalaya, Barshi, India
Dickert, Franz L., Vienna University, Austria
Dieguez, Angel, University of Barcelona, Spain
Dimitropoulos, Panos, University of Thessaly, Greece
Ding, Jianning, Jiangsu Polytechnic University, China
Djordjevic, Alexandar, City University of Hong Kong, Hong Kong
Donato, Nicola, University of Messina, Italy
Donato, Patricio, Universidad de Mar del Plata, Argentina

Dong, Feng, Tianjin University, China
Drljaca, Predrag, Intersema Sensoric SA, Switzerland
Dubey, Venketesh, Bournemouth University, UK
Enderle, Stefan, Univ. of Ulm and KTB Mechatronics GmbH, Germany
Erdem, Gursan K. Arzum, Ege University, Turkey
Erkmen, Aydan M., Middle East Technical University, Turkey
Estelle, Patrice, Insa Rennes, France
Estrada, Horacio, University of North Carolina, USA
Faiz, Adil, INSA Lyon, France
Fericean, Sorin, Balluff GmbH, Germany
Fernandes, Joana M., University of Porto, Portugal
Francioso, Luca, CNR-IMM Institute for Microelectronics and Microsystems, Italy
Francis, Laurent, University Catholique de Louvain, Belgium
Fu, Weiling, South-Western Hospital, Chongqing, China
Gaura, Elena, Coventry University, UK
Geng, Yanfeng, China University of Petroleum, China
Gole, James, Georgia Institute of Technology, USA
Gong, Hao, National University of Singapore, Singapore
Gonzalez de la Rosa, Juan Jose, University of Cadiz, Spain
Granel, Annette, Goteborg University, Sweden
Graff, Mason, The University of Texas at Arlington, USA
Guan, Shan, Eastman Kodak, USA
Guillet, Bruno, University of Caen, France
Guo, Zhen, New Jersey Institute of Technology, USA
Gupta, Narendra Kumar, Napier University, UK
Hadjiloucas, Sillas, The University of Reading, UK
Haider, Mohammad R., Sonoma State University, USA
Hashsham, Syed, Michigan State University, USA
Hasni, Abdelhafid, Bechar University, Algeria
Hernandez, Alvaro, University of Alcalá, Spain
Hernandez, Wilmar, Universidad Politécnica de Madrid, Spain
Homencovschi, Dorel, SUNY Binghamton, USA
Horstman, Tom, U.S. Automation Group, LLC, USA
Hsiai, Tzung (John), University of Southern California, USA
Huang, Jeng-Sheng, Chung Yuan Christian University, Taiwan
Huang, Star, National Tsing Hua University, Taiwan
Huang, Wei, PSG Design Center, USA
Hui, David, University of New Orleans, USA
Jaffrezic-Renault, Nicole, Ecole Centrale de Lyon, France
Jaime Calvo-Galleg, Jaime, Universidad de Salamanca, Spain
James, Daniel, Griffith University, Australia
Janting, Jakob, DELTA Danish Electronics, Denmark
Jiang, Liudi, University of Southampton, UK
Jiang, Wei, University of Virginia, USA
Jiao, Zheng, Shanghai University, China
John, Joachim, IMEC, Belgium
Kalach, Andrew, Voronezh Institute of Ministry of Interior, Russia
Kang, Moonho, Sunmoon University, Korea South
Kaniusas, Eugenijus, Vienna University of Technology, Austria
Katake, Anup, Texas A&M University, USA
Kausel, Wilfried, University of Music, Vienna, Austria
Kavasoglu, Nese, Mugla University, Turkey
Ke, Cathy, Tyndall National Institute, Ireland
Khelfaoui, Rachid, Université de Bechar, Algeria
Khan, Asif, Aligarh Muslim University, Aligarh, India
Kim, Min Young, Kyungpook National University, Korea South
Ko, Sang Choon, Electronics. and Telecom. Research Inst., Korea South
Kockar, Hakan, Balikesir University, Turkey
Kotulska, Malgorzata, Wroclaw University of Technology, Poland
Kratz, Henrik, Uppsala University, Sweden
Kumar, Arun, University of South Florida, USA
Kumar, Subodh, National Physical Laboratory, India

Kung, Chih-Hsien, Chang-Jung Christian University, Taiwan
Lacnjevac, Caslav, University of Belgrade, Serbia
Lay-Ekuakille, Aime, University of Lecce, Italy
Lee, Jang Myung, Pusan National University, Korea South
Lee, Jun Su, Amkor Technology, Inc. South Korea
Lei, Hua, National Starch and Chemical Company, USA
Li, Genxi, Nanjing University, China
Li, Hui, Shanghai Jiaotong University, China
Li, Xian-Fang, Central South University, China
Liang, Yuanchang, University of Washington, USA
Liawruangrath, Saisunee, Chiang Mai University, Thailand
Liew, Kim Meow, City University of Hong Kong, Hong Kong
Lin, Hermann, National Kaohsiung University, Taiwan
Lin, Paul, Cleveland State University, USA
Linderholm, Pontus, EPFL - Microsystems Laboratory, Switzerland
Liu, Aihua, University of Oklahoma, USA
Liu Changgeng, Louisiana State University, USA
Liu, Cheng-Hsien, National Tsing Hua University, Taiwan
Liu, Songqin, Southeast University, China
Lodeiro, Carlos, University of Vigo, Spain
Lorenzo, Maria Encarnacio, Universidad Autonoma de Madrid, Spain
Lukasiewicz, Jerzy Pawel, Nicholas Copernicus University, Poland
Ma, Zhanfang, Northeast Normal University, China
Majstorovic, Vidosav, University of Belgrade, Serbia
Marquez, Alfredo, Centro de Investigacion en Materiales Avanzados, Mexico
Matay, Ladislav, Slovak Academy of Sciences, Slovakia
Mathur, Prafull, National Physical Laboratory, India
Maurya, D.K., Institute of Materials Research and Engineering, Singapore
Mekid, Samir, University of Manchester, UK
Melnyk, Ivan, Photon Control Inc., Canada
Mendes, Paulo, University of Minho, Portugal
Mennell, Julie, Northumbria University, UK
Mi, Bin, Boston Scientific Corporation, USA
Minas, Graca, University of Minho, Portugal
Moghavvemi, Mahmoud, University of Malaya, Malaysia
Mohammadi, Mohammad-Reza, University of Cambridge, UK
Molina Flores, Esteban, Benemérita Universidad Autónoma de Puebla, Mexico
Moradi, Majid, University of Kerman, Iran
Morello, Rosario, University "Mediterranea" of Reggio Calabria, Italy
Mounir, Ben Ali, University of Sousse, Tunisia
Mulla, Imtiaz Sirajuddin, National Chemical Laboratory, Pune, India
Nabok, Aleksey, Sheffield Hallam University, UK
Neelamegam, Periasamy, Sastra Deemed University, India
Neshkova, Milka, Bulgarian Academy of Sciences, Bulgaria
Oberhammer, Joachim, Royal Institute of Technology, Sweden
Ould Lahoucine, Cherif, University of Guelma, Algeria
Pamidighanta, Sayanu, Bharat Electronics Limited (BEL), India
Pan, Jisheng, Institute of Materials Research & Engineering, Singapore
Park, Joon-Shik, Korea Electronics Technology Institute, Korea South
Penza, Michele, ENEA C.R., Italy
Pereira, Jose Miguel, Instituto Politecnico de Seteбал, Portugal
Petsev, Dimiter, University of New Mexico, USA
Pogacnik, Lea, University of Ljubljana, Slovenia
Post, Michael, National Research Council, Canada
Prance, Robert, University of Sussex, UK
Prasad, Ambika, Gulbarga University, India
Prateepasen, Asa, Kingmoungut's University of Technology, Thailand
Pullini, Daniele, Centro Ricerche FIAT, Italy
Pumera, Martin, National Institute for Materials Science, Japan
Radhakrishnan, S., National Chemical Laboratory, Pune, India
Rajanna, K., Indian Institute of Science, India
Ramadan, Qasem, Institute of Microelectronics, Singapore
Rao, Basuthkar, Tata Inst. of Fundamental Research, India
Raoof, Kosai, Joseph Fourier University of Grenoble, France
Reig, Candid, University of Valencia, Spain
Restivo, Maria Teresa, University of Porto, Portugal
Robert, Michel, University Henri Poincare, France
Rezazadeh, Ghader, Urmia University, Iran
Royo, Santiago, Universitat Politècnica de Catalunya, Spain
Rodriguez, Angel, Universidad Politécnica de Cataluña, Spain
Rothberg, Steve, Loughborough University, UK
Sadana, Ajit, University of Mississippi, USA
Sadeghian Marnani, Hamed, TU Delft, The Netherlands
Sandacci, Serghei, Sensor Technology Ltd., UK
Schneider, John K., Ultra-Scan Corporation, USA
Sengupta, Deepak, Advance Bio-Photonics, India
Shah, Kriyang, La Trobe University, Australia
Sapozhnikova, Ksenia, D.I.Mendeleyev Institute for Metrology, Russia
Saxena, Vibha, Bhabha Atomic Research Centre, Mumbai, India
Seif, Selemanni, Alabama A & M University, USA
Seifter, Achim, Los Alamos National Laboratory, USA
Silva Girao, Pedro, Technical University of Lisbon, Portugal
Singh, V. R., National Physical Laboratory, India
Slomovitz, Daniel, UTE, Uruguay
Smith, Martin, Open University, UK
Soleymanpour, Ahmad, Damghan Basic Science University, Iran
Somani, Prakash R., Centre for Materials for Electronics Technol., India
Srinivas, Talabattula, Indian Institute of Science, Bangalore, India
Srivastava, Arvind K., NanoSonix Inc., USA
Stefan-van Staden, Raluca-Ioana, University of Pretoria, South Africa
Sumriddetchka, Sarun, National Electronics and Computer Technology Center, Thailand
Sun, Chengliang, Polytechnic University, Hong-Kong
Sun, Dongming, Jilin University, China
Sun, Junhua, Beijing University of Aeronautics and Astronautics, China
Sun, Zhiqiang, Central South University, China
Suri, C. Raman, Institute of Microbial Technology, India
Sysoev, Victor, Saratov State Technical University, Russia
Szewczyk, Roman, Industrial Research Inst. for Automation and Measurement, Poland
Tan, Ooi Kiang, Nanyang Technological University, Singapore
Tang, Dianping, Southwest University, China
Tang, Jaw-Luen, National Chung Cheng University, Taiwan
Teker, Kasif, Frostburg State University, USA
Thirunavukkarasu, I., Manipal University Karnataka, India
Thumbavanam Pad, Kartik, Carnegie Mellon University, USA
Tian, Gui Yun, University of Newcastle, UK
Tsiantos, Vassilios, Technological Educational Institute of Kaval, Greece
Tsigara, Anna, National Hellenic Research Foundation, Greece
Twomey, Karen, University College Cork, Ireland
Valente, Antonio, University, Vila Real, - U.T.A.D., Portugal
Vanga, Raghav Rao, Summit Technology Services, Inc., USA
Vaseashta, Ashok, Marshall University, USA
Vazquez, Carmen, Carlos III University in Madrid, Spain
Vieira, Manuela, Instituto Superior de Engenharia de Lisboa, Portugal
Vigna, Benedetto, STMicroelectronics, Italy
Vrba, Radimir, Brno University of Technology, Czech Republic
Wandelt, Barbara, Technical University of Lodz, Poland
Wang, Jiangping, Xi'an Shiyou University, China
Wang, Kedong, Beihang University, China
Wang, Liang, Pacific Northwest National Laboratory, USA
Wang, Mi, University of Leeds, UK
Wang, Shinn-Fwu, Ching Yun University, Taiwan
Wang, Wei-Chih, University of Washington, USA
Wang, Wensheng, University of Pennsylvania, USA
Watson, Steven, Center for NanoSpace Technologies Inc., USA
Weiping, Yan, Dalian University of Technology, China
Wells, Stephen, Southern Company Services, USA
Wolkenberg, Andrzej, Institute of Electron Technology, Poland
Woods, R. Clive, Louisiana State University, USA
Wu, DerHo, National Pingtung Univ. of Science and Technology, Taiwan
Wu, Zhaoyang, Hunan University, China
Xiu Tao, Ge, Chuzhou University, China
Xu, Lisheng, The Chinese University of Hong Kong, Hong Kong
Xu, Sen, Drexel University, USA
Xu, Tao, University of California, Irvine, USA
Yang, Dongfang, National Research Council, Canada
Yang, Shuang-Hua, Loughborough University, UK
Yang, Wuqiang, The University of Manchester, UK
Yang, Xiaoling, University of Georgia, Athens, GA, USA
Yaping Dan, Harvard University, USA
Ymeti, Aurel, University of Twente, Netherland
Yong Zhao, Northeastern University, China
Yu, Haihu, Wuhan University of Technology, China
Yuan, Yong, Massey University, New Zealand
Yufera Garcia, Alberto, Seville University, Spain
Zakaria, Zulkarnay, University Malaysia Perlis, Malaysia
Zagnoni, Michele, University of Southampton, UK
Zamani, Cyrus, Universitat de Barcelona, Spain
Zeni, Luigi, Second University of Naples, Italy
Zhang, Minglong, Shanghai University, China
Zhang, Qintao, University of California at Berkeley, USA
Zhang, Weiping, Shanghai Jiao Tong University, China
Zhang, Wenming, Shanghai Jiao Tong University, China
Zhang, Xueji, World Precision Instruments, Inc., USA
Zhong, Haoxiang, Henan Normal University, China
Zhu, Qing, Fujifilm Dimatix, Inc., USA
Zorzano, Luis, Universidad de La Rioja, Spain
Zourob, Mohammed, University of Cambridge, UK

Contents

Volume 124
Issue 1
January 2011

www.sensorsportal.com

ISSN 1726-5479

Research Articles

Investigation of Magnetic-field-induced Temperature Error of Pt- 500 <i>Rajinikumar Ramalingam and Michael Schwarz</i>	1
Classification of Unknown Thermocouple Types Using Similarity Factor Measurement <i>Seshu K. Damarla and Palash Kundu</i>	11
The Design of a Novel Flexible Tactile Sensor Based on Pressure-conductive Rubber <i>Fei Xu, Yunjian Ge, Yong Yu, Junxiang Ding, Tao Ju, Shanhong Li</i>	19
Study on the Relative Difference of the Force Transducer Constants in Tensile and Compressive Modes Calibration Equations <i>Ebtisam H. Hasan and Seif. M. Osman</i>	30
Design of a Large-scale Three-dimensional Flexible Arrayed Tactile Sensor <i>Junxiang Ding, Yunjian Ge, Shanhong Li, Fei Xu, Feng Shuang</i>	37
The Activity Airflow Detection of Vehicle Intake System Using Hot-film Anemometry Sensors Instrument <i>Rong-Hua Ma and Chi-Kuen Sung</i>	48
Hardware Developments of an Ultrasonic Tomography Measurement System <i>Hudabiyah Arshad Amari, Ruzairi Abdul Rahim, Mohd Hafiz Fazalul Rahiman, Herlina Abdul Rahim, Muhammad Jaysuman Pusppanathan</i>	56
Design and Development of Microcontroller Based Fluoride Meter <i>Bhaskar Reddy S., V. V. Ramana C. H. and Malakondaiah K.</i>	64
Effect of Magnetic Flux Density and Applied Current on Temperature, Velocity and Entropy Generation Distributions in MHD Pumps <i>M. Kiyasatfar, N. Pourmahmoud, M. M. Golzan, M. Eskandarzade</i>	72
Design of a DCS Based Model for Continuous Leakage Monitoring System of Rotary Air Preheater of a Thermal Power Plant <i>Madan Bhowmick and Satish Chandra Bera</i>	83
The Design of a Wireless Monitoring System for Unattended Environmental Applications <i>Ibrahim Al-Bahadly and Victor Mtetwa</i>	101
Performance Measures of Ultra-Wideband Communication System <i>Mrutyunjaya Panda, Sarat Kumar Patra</i>	120
Unspecified Low-Frequency Noise in Chopper Op-Amps <i>Charles Gilbert</i>	127

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/Submission.htm>



The Third International Conference on Bioinformatics, Biocomputational Systems and Biotechnologies

BIOTECHNO 2011

May 22-27, 2011 - Venice, Italy



Tracks:

A. Bioinformatics, chemoinformatics, neuroinformatics and applications

- Bioinformatics
- Advanced biocomputation technologies
- Chemoinformatics
- Bioimaging
- Neuroinformatics

B. Computational systems

- Bio-ontologies and semantics
- Biocomputing
- Genetics
- Molecular and Cellular Biology
- Microbiology

C. Biotechnologies and biomanufacturing

- Fundamentals in biotechnologies
- Biodevices
- Biomedical technologies
- Biological technologies
- Biomanufacturing

Important deadlines:

Submission (full paper)	January 10, 2011
Notification	February 20, 2011
Registration	March 5, 2011
Camera ready	March 20, 2011

<http://www.iaria.org/conferences2011/BIOTECHNO11.html>



The Seventh International Conference on Networking and Services

ICNS 2011

May 22-27, 2011 - Venice, Italy



Important deadlines:

Submission (full paper)	January 10, 2011
Notification	February 20, 2011
Registration	March 5, 2011
Camera ready	March 20, 2011

<http://www.iaria.org/conferences2011/ICNS11.html>

Tracks:

- ENCOT: Emerging Network Communications and Technologies
- COMAN: Network Control and Management
- SERVI: Multi-technology service deployment and assurance
- NGNUS: Next Generation Networks and Ubiquitous Services
- MPQSI: Multi Provider QoS/SLA Internetworking
- GRIDNS: Grid Networks and Services
- EDNA: Emergency Services and Disaster Recovery of Networks and Applications
- IPv6DFI: Deploying the Future Infrastructure
- IPDy: Internet Packet Dynamics
- GOBS: GRID over Optical Burst Switching Networks



The Sixth International Conference on Systems

ICONS 2011

January 23-28, 2011 - St. Maarten,
The Netherlands Antilles



Important deadlines:

Submission (full paper)	September 25, 2010
Notification	October 20, 2010
Registration	November 5, 2010
Camera ready	November 5, 2010

<http://www.iaria.org/conferences2011/ICONS11.html>

Tracks:

- Systems' theory and practice
- System engineering
- System instrumentation
- Embedded systems and systems-on-the-chip
- Target-oriented systems [emulation, simulation, prediction, etc.]
- Specialized systems [sensor-based, mobile, multimedia, biometrics, etc.]
- Validation systems
- Security and protection systems
- Advanced systems [expert, tutoring, self-adapting, interactive, etc.]
- Application-oriented systems [content, eHealth, radar, financial, vehicular, etc.]
- Safety in industrial systems
- Complex Systems

Hardware Developments of an Ultrasonic Tomography Measurement System

¹Hudabiyah ARSHAD AMARI, ¹Ruzairi ABDUL RAHIM,
²Mohd Hafiz FAZALUL RAHIMAN, ¹Herlina ABDUL RAHIM,
³Muhammad Jaysuman PUSPPANATHAN

¹Process Tomography Research Group, Control & Instrumentation Engineering Department,
Faculty of Electrical Engineering, Universiti Teknologi Malaysia,
81310 Skudai, Johor Bahru, Malaysia

Tel.: +607-5537801, E-mail: ruzairi@fke.utm.my

²Tomography Imaging Research Group, School of Mechatronic Engineering,
Universiti Malaysia Perlis, Ulu Pauh Campus, 02600 Arau, Perlis, Malaysia

Tel.: +604 9885166, E-mail: hafiz@unimap.edu.my

³FX Sigma, Taman Universiti, 81300 Skudai, Malaysia

Received: 19 November 2010 /Accepted: 24 January 2011 /Published: 28 January 2011

Abstract: This research provides new technique in ultrasonic tomography by using ultrasonic transceivers instead of using separate transmitter-receiver pair. The numbers of sensors or transducers used to acquire data plays an important role to generate high resolution tomography images. The configuration of these sensors is a crucial factor in the efficiency of data acquisition. Instead of using common separated transmitter – receiver, an alternative approach has been taken to use dual functionality ultrasonic transceiver. A prototype design of sensor's jig that will hold 16 transceivers of 14.1mm has been design. Transmission-mode approach with fan beam technique has been used for sensing the flow of gas, liquid and solid. This paper also explains the circuitry designs for the Ultrasonic Tomography System. *Copyright © 2011 IFSA.*

Keywords: Transceivers, Ultrasonic tomography system, Non-invasive imaging.

1. Introduction

Process tomography refers to a method of acquiring the internal characteristics of pipelines flows or process vessel reaction from the measurements on the domain of interest. Current industries are

increasingly interested in this field as tomography brings much applications as well as advantages to the system. Over two decades of research worldwide, process tomography has become a routine research tool in many research laboratories and is being accepted for process measurement and control in some industrial applications. In chemical process, tomography will be useful to estimate the spatial distribution of phases and chemicals inside their processing vessels or pipelines, giving instant feedback on reaction processes, or efficiency of transport. The 3D images can be reconstructed from non-invasive peripheral sensing which make it easier to monitor the internal reaction of online process. In pharmaceuticals and fine chemicals, monitoring the critical processes of high value products is essential, and in the food industry, tomography offers great insights into the structural transformations found in colloids and gels. In mineral engineering, tomography can monitor separation and transport operations continuously, helping ensure maximum production. While in the oil and gas industries, process tomography can deliver valuable information for a variety of processes such as, characterization of multiphase flows, separation of multiphase components and homogeneity of packed beds and process vessels [1, 14]. In addition, process tomography can be valuable tool in testing and validation of process models such as computational fluid dynamics (CFD).

2. Ultrasonic Process Tomography

Various techniques exist in process tomography, so the best and suitable technique should be choose depends on the components inside the vessels in this case solid, liquid and gas. Ultrasonic process tomography is useful for imaging processes where differences in object density and elasticity offer the most significant sensing opportunity [2]. In general the object will interact with an ultrasound beam through some form of acoustic scattering. The interaction may then be sensed to yield information about the object or field [3].

There are three types of sensing techniques which is transmission mode, reflection sensing mode and diffraction mode [4]. In this paper, the transmission-mode technique was utilized. The transmission mode technique is based on the measurement of the changed in the properties of the transmitted acoustic wave. Then, it gives advantages over the other techniques since there are three different intensity of material in the measuring pipe which gives different acoustic impedance of each material. The systems consists of ultrasonic pulse generators to excite the transducers to transmits and receive the waves. The information gathered then will be process to develop the reconstructed images of components inside the process vessels.

In the study of tomography, the physical principle of a sensing systems depends on the reconstructed image of the cross sectional distribution of the parameter. It is evaluated by arraying ultrasonic sensors non-invasively on the surface of the vessel. By using the electronic circuits to interface, the data captured can be processes and analyzed by the computer to reveal the information of the internal dynamic characteristics [5, 7].

3. Hardware Developments

One of the most important parts in ultrasonic tomography system is the front end that is the transducer array and associated electronic hardware. This is important for acquiring the data needed to produce a meaningful image. This is fundamental to the success or failure of an acoustic imaging system. Therefore, given the object to be imaged and the specifications to be achieved, the design of the front end of an acoustic imaging system should be regarded as a first priority [8].

3.1. Hardware Developments

Ultrasonic transceiver is a type of transducer that converts electrical energy into high frequency sound waves and also converting sound waves back to electrical energy. It contains piezoelectric crystal materials that have the ability to transform mechanical energy into electrical energy and vice versa [7]. Piezoelectric crystals have the property of changing size when a voltage is applied, thus applying an alternating current (AC) across them causes them to oscillate at very high frequencies, thus producing very high frequency sound waves.

For using piezoelectric transceiver, certain characteristics need to be evaluated to determine the properties of the transceiver that suitable for specific application. For instance, the size, frequency, sensitivity, beam angle, driving voltage and others. Selection for the right transceivers is the first priority since it is in the front-end of the ultrasonic tomography system together with associated hardware. Other factors that contribute to the selection of the sensor are the sound pressure level (SPL) and the centre frequency shift against temperature variations [9].

3.2. Sensor Arrangement

A sensor jig as in Fig. 1 was designed to put the sensor into order well around the pipe vessel. It was fabricated to fit 16 transceiver of size 14.1 mm. The jig is created with accurate position, angle and thickness for each sensor. The use of sensor jig will reduce the error of the projected signal due to the echo effect [10].



Fig. 1. Sensor Jig.

All 16 transceivers are enclosed in the jig that designed for 100 mm pipe diameter. This situation shows the advantage of using transceiver rather than using separate transmitter receiver sensor. Since the number of sensors may improve the quality of reconstructed image, transceivers are the best choice. Transceivers have dual functionality which can be switch either as transmitter or receiver. Thus, it will give about half extra space to locate the transceiver around the pipe. For example, by using common ultrasonic sensors functioning separately, only 8 transmitters and 8 receivers can be applied instead of using dual functionality transceiver, 16 sensors be able to installed.

When a transceiver is set to be transmitter, the other transceiver will be functioning as receivers. It will be connect to transmitter circuit when function to transmit and connect to receiver circuit when function to receive. The timing circuit is very important since incorrect switching timing leads to inaccurate measurement data [11].

The cross section of the sensor arrangement shown in Fig. 2 which is also an example of fan shaped beam sensor array. The transceivers enable the transmission and reception on the same sensor.

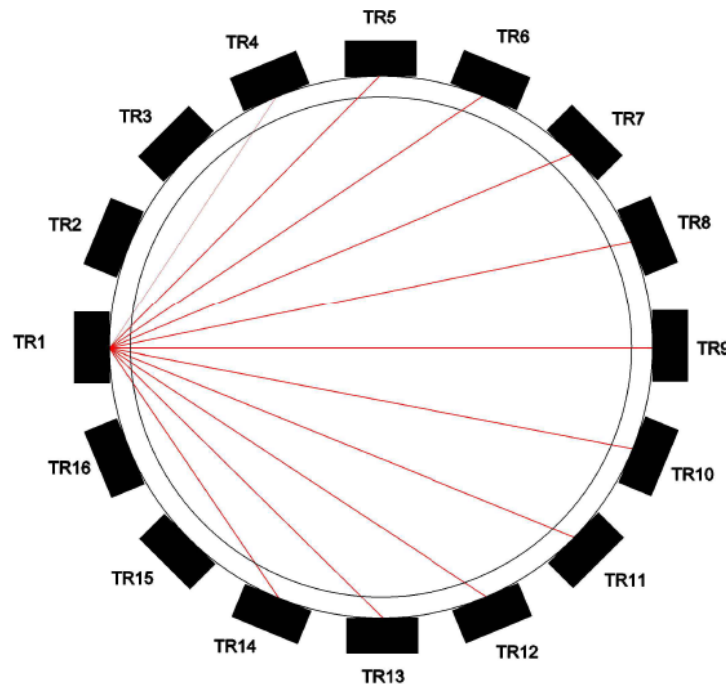


Fig. 2. Ultrasonic Transceivers Sensor Arrangement.

The transceiver chosen has 125° beam angle and from Fig. 2, it clearly shown that only 11 transceiver are within the region. The other 5 are outside the boundary including the excite one. So, there are 11 measurement in one projection, therefore totally 176 measurement will be obtain. Compared to separate transmitter receiver with same beam angle on a same diameter of pipe and same sensor size only, 6 sensors within the boundary with total of 48 measurements will be taken. Therefore results in image generated that much fuzzier.

3.3. Electronic Circuit

In tomography system, the front-end is important as it need to obtain data with high accuracy since the measurement data are used for image reconstruction part. The Fig. 3 shows the block diagram of ultrasonic tomography system. The microcontroller unit (PIC18F4520) is used as signal generator to generate a 40 kHz signals to transmitters while the receiver will received the projected signals [8, 12]. The readings from receiving transceivers are sent to the signal conditioning circuit. The output of this circuit will go through peak detector circuits which then are sent to personal computer via USB connection from the DAQ system for image reconstruction. In this research, the Data Acquisition System, NI USB 6218 from National Instruments is use to acquire and transfer the data via LabView software.

The signal generator circuit was designed using low noise high-performance; internally compensated operational amplifiers built using Texas Instruments complementary bipolar Excalibur process, which act as comparator as shown in Fig. 4. The comparator will generate 30 Vp-p tone burst of 40 kHz with reverberation delay of 100 Hz. The duration for every pulse generation is chosen because within this delay time, the reverberation effects will stop before new excitation is activated.

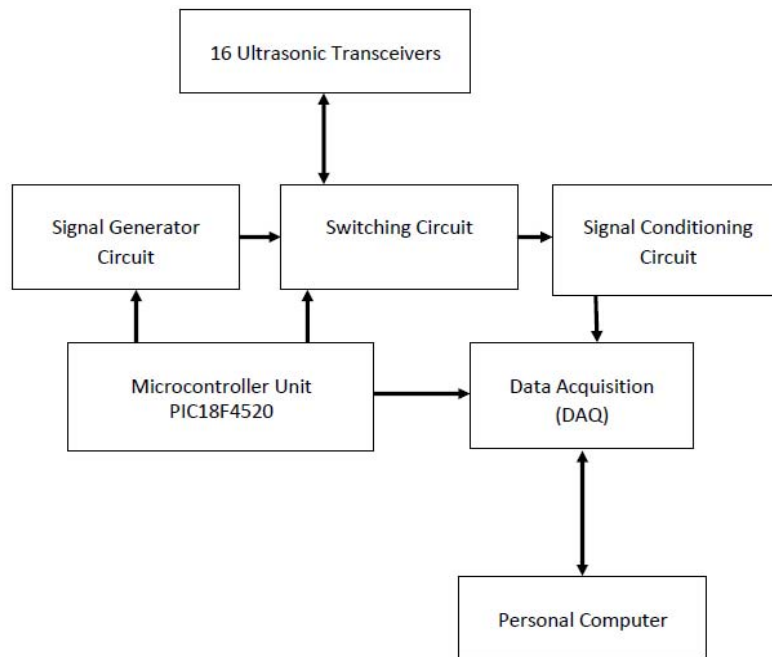


Fig. 3. Block Diagram of Ultrasonic Tomography System.

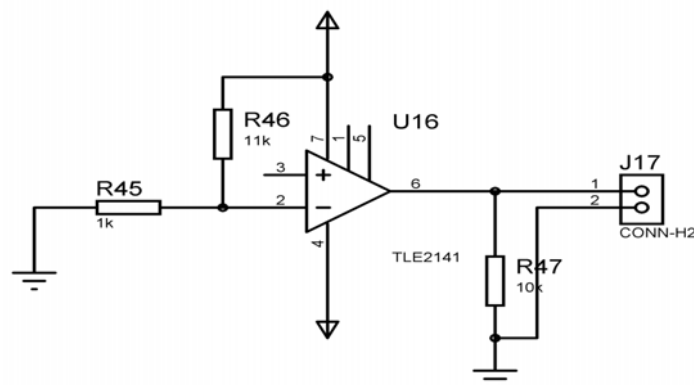


Fig. 4. Signal Generator Circuit.

The signal conditioning circuit consists of two components which is signal receiving circuit and peak detector circuit as shown in Fig. 5 and Fig. 6. The receiving circuit which also is an amplifier circuit using the audio operational amplifier, LM833. This op-amp is a high speed op-amp with excellent phase margin and stability. The amplifier was design in two stages with inverting amplifier connection. The first stage is the pre-amplifier with gain $AA = -120$ and the second stage is to amplify with gain $AB = -120$. The received signals are amplified through these two stages to amplify twice.

A peak detector is a series connection of a diode and a capacitor outputting a DC voltage equal to the peak value of the applied AC signal. The circuit is shown in Fig. 6, an AC voltage source applied to the peak detector, charges the capacitor to the peak of the input. The diode conducts positive half cycles charging the capacitor to the waveform peak. When the input waveform falls below the DC peak stored on the capacitor, the diode is reverse biased, blocking current flow from capacitor back to the source.

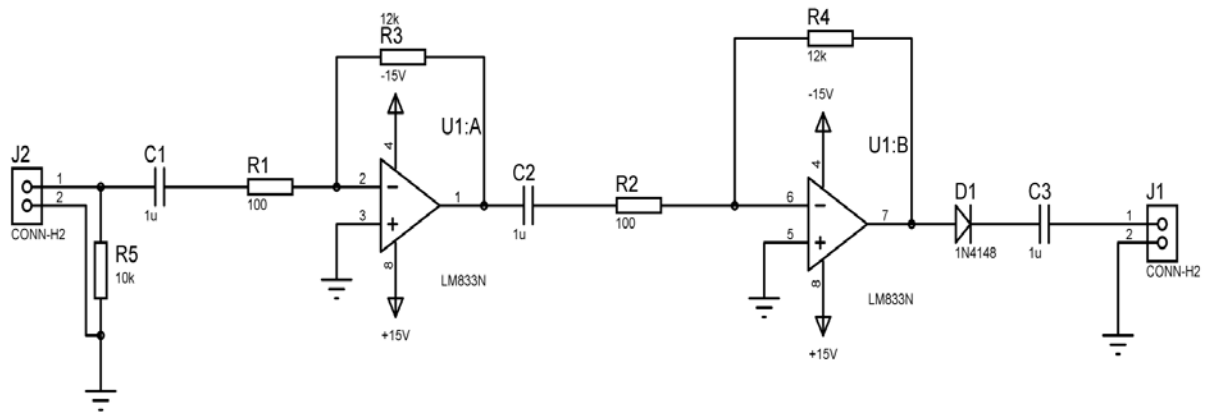


Fig. 5. Signal Receiving Circuit.

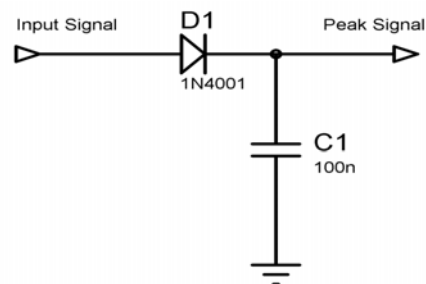


Fig. 6. Peak Detector Circuit.

4. Results

The signals shown in Fig. 7 are transmitting pulse tone of transmitter 1 (yellow) and receiving signal by the receiver 9 (blue) captured using oscilloscope. Amplifying the received ultrasonic signals is vital because the original receive signal might be too small and hard to process in the next level. However, the amplified gain must not be too large as the output signal will saturated in which the signals might be clipped out at positive and negative peak. This will bring an error to the final results. As be seen in the receive wave, there is a slight distortion occur. This is because, the wave are going through several layer before reaching the receiver. It has to penetrate the pipe wall then go through the water or components inside and break in the wall again before reaching the receiver.

Peak detector output is shown in Fig. 8 (blue). It changes AC ultrasonic wave from the receiver signals above into a DC voltage. The peak detector will capture the most high peak signal to be changed to DC signal. Then, the highest voltage as shown in Fig. 8 will be taken for further imaging reconstruction. The implementation of this peak detector circuit will give faster response time as well as simpler integration into the system and also for more compact board design [13].

5. Conclusions

The use of transceiver proved to give more spaces and furthermore extra data can be collected which gives better results in image reconstruction later on. The use of peak detection concept in the circuitry systems gives much simpler and less complexity in signal conditioning circuits. It will automatically detect the peak signal of the ultrasound wave. Nevertheless, the system has to bear out of heavy noise so that the peak detector would not sample the false data. Thus the system needs to be robust.

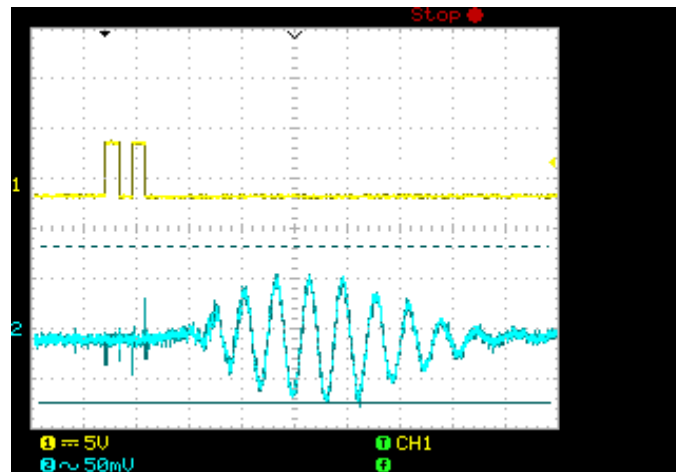


Fig. 7. Ultrasonic Pulse tones and Receiver Signals.

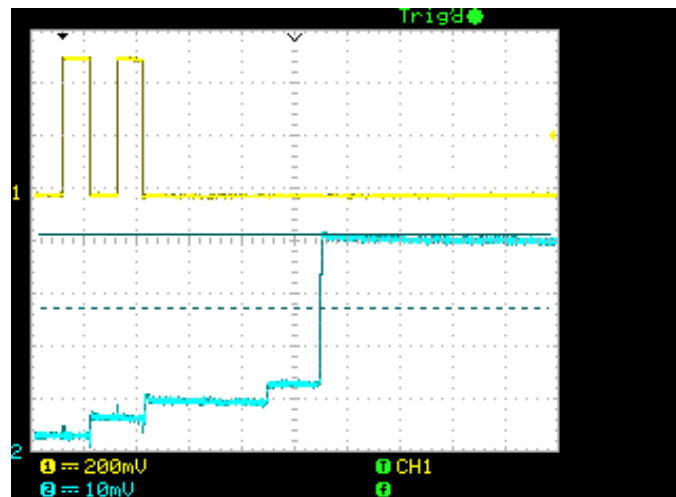


Fig. 8. Peak Detector Output.

References

- [1]. Zakaria Z, Fazalul Rahiman M. H., Abdul Rahim R., Simulation of the Two-Phase Liquid – Gas Flow through Ultrasonic Transceivers Application in Ultrasonic Tomography, *Sensor & Transducer*, Vol. 112, Issue 1, January 2010, pp. 24-38.
- [2]. Williams R. A, Beck M. S., Process Tomography: Principles, techniques and applications, *Butterworth-Heinemann Ltd.*, 1995.
- [3]. Li, W, Hoyle B. S., Ultrasonic Process Tomography using Multiple Active sensors for Maximum Real-Time Performance, *Chemical Engineering Science*, Vol. 52, Issue 13, 1997, pp. 2161-2170.
- [4]. Reinecke N, Petrisch G., Schmitz D, Mewes D., Tomographic Measurement Techniques: Visualization of Multiphase Flows, *Chemical Engineering Technology*, Vol. 21, 1998, pp. 7-18.
- [5]. Hoyle B. S., Process Tomography using Ultrasonic sensors, *Measurement Science Technology*, Vol. 7, 1996, pp. 272-280.
- [6]. Xu L. J, Xu L. A., Gas/Liquid Two-Phase Flow Regime Identification by Ultrasonic Tomography, *Flow Measurement and Instrumentation Journal*, Vol. 8, 1997, pp. 145-155.
- [7]. Fazalul Rahiman M. H, Abdul Rahim R., Development of Ultrasonic Transmission-mode Tomography for Water-Particles Flow, *Sensors & Transducers*, Vol. 117, Issue 6, 2010, pp. 99-105.
- [8]. Zakaria Z, Fazalul Rahiman M. H, Abdul Rahim R, Salleh A. F, Jahidin A. H., Ultrasonic Tomography; the Applications of 32 Transceivers Technique in Two Phase Flow Imaging, in Proc. of the *International*

Conference on Control, Instrumentation and Mechatronics Engineering (CIM '09), June 2009, Mallaca, Malaysia.

- [9]. Ibrahim, S. & Syed Salim, S. N., Ultrasonic process tomography, in *Proc. of the 1st International Conference on Control, Instrumentation and Mechatronics (CIM 2007)*, 28 – 29 May, 2007, Johor Bahru, Malaysia.
- [10]. Fazalul Rahiman M. H, Abdul Rahim R, Yaacob S, Zakaria Z, Manan M. R., A Comparative Study on Ultrasonic Transceiver Sensing Array for Bubbly Gas Hold Ups, in *Proc. of the International Conference on Control, Instrumentation and Mechatronics Engineering (CIM '09)*, June 2009, Mallaca, Malaysia.
- [11]. R. Abdul Rahim, M. H. Fazalul Rahiman, W. N. Ng, K. S. Chan., Initial Results on Monitoring Liquid/Gas Flow using Ultrasonic Tomography. *Jurnal Teknologi*, Universiti Teknologi Malaysia, Vol. 40, 2004, pp. 77-88.
- [12]. M. H. Fazalul Rahiman, R. Abdul Rahim, M. H. Fazalul Rahiman, M. Tajuddin, Ultrasonic Transmission-Mode Tomography Imaging for Liquids/Gas Two-Phase Flow, *IEEE Sensors Journal*, Vol. 6, No. 6, 2006, pp. 1706 – 1715.
- [13]. N. M. Nor Ayob, M. H. Fazalul Rahiman, S. Yaacob, R. Abdul Rahim, Ultrasound Processing Circuitry for Ultrasonic Tomography, in *Proc. of the International Conference on Man Machine Systems (ICoMMS)*, 11-13 October 2009, Perlis, Malaysia.

2011 Copyright ©, International Frequency Sensor Association (IFSA). All rights reserved.
(<http://www.sensorsportal.com>)



SENSORS APPLICATIONS SYMPOSIUM

Hyatt Regency San Antonio
February 22-24, 2011
San Antonio, TX



The 2011 IEEE sensors Applications Symposium (SAS-2011) provides an established forum for sensor users and developers to meet and exchange information about novel and emergent applications in smart sensors, homeland security, biology, system health management, and related areas. Collaborate and network with scientists, engineers, developers and customers, in a balance of formal technical presentations, workshops, and informal interface meetings. Suggested topics for SAS-2011 include:

Sensors

- Biosensors/Arrays
- Smart sensors and standards
- Sensor networking
- MEMS and nanosensors
- Virtual sensors

Sensor Applications

- Homeland security
- Multisensor data fusion
- Nondestructive evaluation and remote sensing
- Integrated systems health management (ISHM)
- Commercial development




For additional information, please visit the Sensors Applications Symposium website at www.sensorapps.org

Conference Co-Chairs:
Shreekanth Mandayam,
Rowan University, USA

Deniz Gurkan,
University of Houston, USA

Technical Program Chair:
Steven Griffin,
University of Memphis, USA

Additional topics for workshops and new session tracks are especially welcome—please contact the organizers. Papers presented at SAS-2011 will be eligible for consideration for publication in a *Special Issue* of the *IEEE Transactions on Instrumentation & Measurement*.

<http://sensorapps.org/>

Important Dates:

- 15 October 2010:
Abstract submission deadline
- 15 November 2010:
Notification of acceptance
- 10 January 2011:
Final manuscript submission deadline



The Second International Conference
on Sensor Device Technologies and Applications

SENSORDEVICES 2011

August 21-27, 2011 - French Riviera, France



Important deadlines:

Submission deadline	March 23, 2011
Notification	April 30, 2011
Registration	May 15, 2011
Camera ready	May 22, 2011

Tracks:

- Sensor devices
- Photonics
- Infrared
- Ultrasonic and Piezosensors
- 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

<http://www.iaria.org/conferences2011/SENSORDEVICES11.html>



The Fifth International Conference on Sensor
Technologies and Applications

SENSORCOMM 2011

August 21-27, 2011 - French Riviera, France



Important deadlines:

Submission deadline	March 23, 2011
Notification	April 30, 2011
Registration	May 15, 2011
Camera ready	May 22, 2011

Tracks:

- APASN: Architectures, protocols and algorithms of sensor networks
- MECSN: Energy, management and control of sensor networks
- RASQOFT: Resource allocation, services, QoS and fault tolerance in sensor networks
- PESMOSN: Performance, simulation and modelling of sensor networks
- SEMOSN: Security and monitoring of sensor networks
- SECSN: Sensor circuits and sensor devices
- RIWISN: Radio issues in wireless sensor networks
- SAPSN: Software, applications and programming of sensor networks
- DAIPSN: Data allocation and information in sensor networks
- DISN: Deployments and implementations of sensor networks
- UNWAT: Under water sensors and systems
- ENOPT: Energy optimization in wireless sensor networks

<http://www.iaria.org/conferences2011/SENSORCOMM11.html>



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

CENICS 2011

August 21-27, 2011 - French Riviera, France



Important deadlines:

Submission deadline	March 23, 2011
Notification	April 30, 2011
Registration	May 15, 2011
Camera ready	May 22, 2011

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/conferences2011/CENICS11.html>

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 addition, 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:

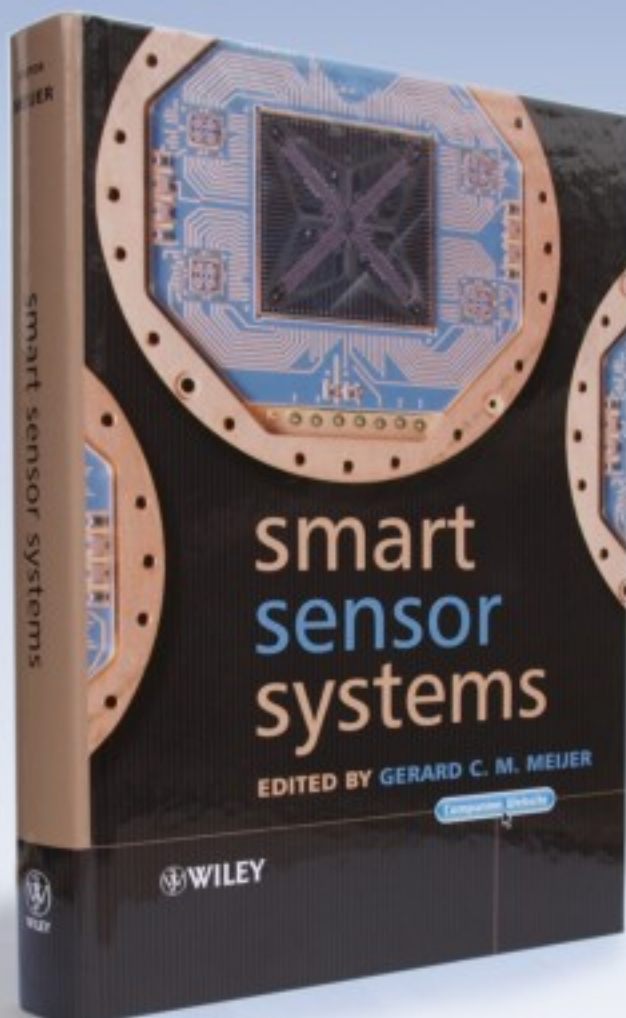
- Physical, chemical and biosensors;
- Digital, frequency, period, duty-cycle, time interval, PWM, pulse number output sensors and transducers;
- Theory, principles, effects, design, standardization and modeling;
- Smart sensors and systems;
- Sensor instrumentation;
- Virtual instruments;
- Sensors 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

Advertising orders and enquires may be sent to sales@sensorsportal.com Please download also our media kit: http://www.sensorsportal.com/DOWNLOADS/Media_Kit_2009.pdf



'Written by an internationally-recognized team of experts, this book reviews recent developments in the field of smart sensors systems, providing complete coverage of all important systems aspects. It takes a multidisciplinary approach to the understanding, design and use of smart sensor systems, their building blocks and methods of signal processing.'



Order online:

http://www.sensorsportal.com/HTML/BOOKSTORE/Smart_Sensor_Systems.htm

www.sensorsportal.com