

# SENSORS & TRANSDUCERS **12** vol. 147 /12

TOTAL US\$ 8.7B

TOTAL US\$ 19.6B



## Sensor Market Trends



**Editors-in-Chief:** professor Sergey Y. Yurish, tel.: +34 696067716, 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

### Editors for North America

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

### Editor South America

Costa-Felix, Rodrigo, Inmetro, Brazil

### Editor for Eastern Europe

Sachenko, Anatoly, Ternopil State Economic University, Ukraine

### Editor for Asia

Ohyama, Shinji, Tokyo Institute of Technology, Japan

### Editor for Africa

Maki K.Habib, American University in Cairo, Egypt

### Editor for Asia-Pacific

Mukhopadhyay, Subhas, Massey University, New Zealand

## Editorial Advisory Board

- Abdul Rahim, Ruzairi**, Universiti Teknologi, Malaysia  
**Ahmad, Mohd Noor**, Nothern 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, Vygtantas**, Kaunas University of Technology, Lithuania  
**Avachit, Patil Lalchand**, North Maharashtra University, India  
**Ayesh, Aladdin**, De Montfort University, UK  
**Azamimi, Azian binti Abdullah**, Universiti Malaysia Perlis, Malaysia  
**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  
**Benachaiba, Chellali**, Universitè 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  
**Bouchikhi, Benachir**, University Moulay Ismail, Morocco  
**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  
**Calvo-Gallego, Jaime**, Universidad de Salamanca, Spain  
**Campanella, Luigi**, University La Sapienza, Italy  
**Carvalho, Vitor**, Minho University, Portugal  
**Cecelja, Franjo**, Brunel University, London, UK  
**Cerda 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**, Universite 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  
**Dighavkar, C. G.**, M.G. Vidyamandir's L. V.H. College, India  
**Dimitropoulos, Panos**, University of Thessaly, Greece  
**Ding, Jianning**, Jiangsu Polytechnic University, China  
**Djordjevich, Alexander**, 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**, Instersema 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  
**Granell, 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 Politecnica de Madrid, Spain  
**Homentcovschi, 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  
**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  
**Kaniasas, 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  
**Kotulska, Malgorzata**, Wroclaw University of Technology, Poland  
**Kockar, Hakan**, Balikesir University, Turkey  
**Kong, Ing**, RMIT University, Australia  
**Kratz, Henrik**, Uppsala University, Sweden

**Krishnamoorthy, Ganesh**, University of Texas at Austin, USA  
**Kumar, Arun**, University of Delaware, Newark, 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, Fengyuan (Thomas)**, Purdue University, USA  
**Li, Genxi**, Nanjing University, China  
**Li, Hui**, Shanghai Jiaotong University, China  
**Li, Sihua**, Agiltron, Inc., USA  
**Li, Xian-Fang**, Central South University, China  
**Li, Yuefa**, Wayne State University, USA  
**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  
**Lukaszewicz, Jerzy Pawel**, Nicholas Copernicus University, Poland  
**Ma, Zhanfang**, Northeast Normal University, China  
**Majstorovic, Vidosav**, University of Belgrade, Serbia  
**Malyshev, V.V.**, National Research Centre 'Kurchatov Institute', Russia  
**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  
**Mishra, Vivekanand**, National Institute of Technology, India  
**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  
**Mrad, Nezh**, Defence R&D, Canada  
**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  
**Passaro, Vittorio M. N.**, Politecnico di Bari, Italy  
**Penza, Michele**, ENEA C.R., Italy  
**Pereira, Jose Miguel**, Instituto Politecnico de Setebal, 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  
**Pugno, Nicola M.**, Politecnico di Torino, Italy  
**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  
**Raouf, Kosai**, Joseph Fourier University of Grenoble, France  
**Rastogi Shiva, K.**, University of Idaho, USA  
**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**, Universitat Politècnica de Catalunya, Spain  
**Rothberg, Steve**, Loughborough University, UK  
**Sadana, Ajit**, University of Mississippi, USA  
**Sadeghian Marnani, Hamed**, TU Delft, The Netherlands  
**Sapozhnikova, Ksenia**, D.I.Mendeleyev Institute for Metrology, Russia  
**Sandacci, Serghei**, Sensor Technology Ltd., UK  
**Saxena, Vibha**, Bbhba Atomic Research Centre, Mumbai, India  
**Schneider, John K.**, Ultra-Scan Corporation, USA  
**Sengupta, Deepak**, Advance Bio-Photonics, India  
**Seif, Selemani**, Alabama A & M University, USA  
**Seifter, Achim**, Los Alamos National Laboratory, USA  
**Shah, Kriyang**, La Trobe University, Australia  
**Sankarraaj, Anand**, Detector Electronics Corp., USA  
**Silva Giraó, Pedro**, Technical University of Lisbon, Portugal  
**Singh, V. R.**, National Physical Laboratory, India  
**Slomovitz, Daniel**, UTE, Uruguay  
**Smith, Martin**, Open University, UK  
**Soleimanpour, Amir Masoud**, University of Toledo, USA  
**Soleymanpour, Ahmad**, University of Toledo, USA  
**Somani, Prakash R.**, Centre for Materials for Electronics Technol., India  
**Sridharan, M.**, Sastra University, 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  
**Stefanescu, Dan Mihai**, Romanian Measurement Society, Romania  
**Sumriddetchka, Sarun**, National Electronics and Comp. Technol. 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**, Industr. 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, Quintao**, 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 147  
Issue 12  
December 2012

www.sensorsportal.com

ISSN 1726-5479

## Research Articles

<b>Constantly Evolving Smartness, Intelligence and Innovation Ensure Seamless System Integration</b> <i>Dr. Rajender Thusu</i> .....	1
<b>An Intelligent Temperature Measurement Technique Using J Type Thermocouple with an Optimal Neural Network</b> <i>Santhosh K. V., B. K. Roy</i> .....	6
<b>Thermal Sensitivity of Solid Polymer Coated Surface Transverse/Love Wave Based Resonators on AT-cut Quartz for Sensor Applications</b> <i>I. D. Avramov and K. D. Esmeryan</i> .....	15
<b>Effect on Passive Localization from the Shape Distortion of Triplet Linear Array Based on Piezoelectric Transducers</b> <i>Fei Xu, Xianlong Liu</i> .....	27
<b>Detecting Water Content in Hydrocarbon Emulsion Using Acoustic and Ultrasonic Detectors</b> <i>Rateb Issa, Ibrahim Al-Abbas and Hussein Sarhan</i> .....	36
<b>Study of Vibration Characteristics of a Multi Cracked Rotating Shaft Using Piezoelectric Sensor</b> <i>Rajeev Ranjan, N. K. Mandal</i> .....	45
<b>An Insole Device Based on Piezoelectric Sensor to Assess Plantar Pressure during Daily Human Activity</b> <i>Yemin Guo</i> .....	53
<b>A Novel Tuning Method for Repeatability Problem Solving of RF MEMS Disk Resonators</b> <i>Masoud Baghelani, Habib Badri Ghavifekr, Afshin Ebrahimi</i> .....	61
<b>FEM Based Optimization of Thin Membrane for Thermoelectric Energy Harvesting Devices</b> <i>Divya Jatain, Monoj Kumar Singha, Ajay Agarwal, Manoj Taleja</i> .....	68
<b>Visual Odometry in Dynamical Scenes</b> <i>Dong Zhang and Ping Li</i> .....	78
<b>An Experimentation on Anti-Reset Windup Scheme for Level Process Station</b> <i>I. Thirunavukkarasu, Mohammed Ibrahim Fareed Abuaiah, V. I. George, S. Shanmuga Priya</i> .....	87
<b>Design and Development of an Instrument to Determine the Fluoride Ion Concentration in Certain Tooth Pastes</b> <i>Saraswathi Parigi, Sreelekha Kande, Nagaraju Boya, Raghavendra Rao Kanchi</i> .....	95

<b>Data Mining Approach to Polymer Selection for Making SAW Sensor Array Based Electronic Nose</b> <i>Sunil K. Jha and R. D. S. Yadava</i> .....	108
<b>Development of a Non-invasive Micron Sized Blood Glucose Sensor Based on Microsphere Stimulated Raman Spectroscopy</b> <i>Alireza Bahrampour, Neda Jahangiri, Majid Taraz</i> .....	129
<b>MOS Device Chemical Response to Acceptor Stimuli</b> <i>Rina Lombardi, Ricardo Aragón and Héctor A. Medina</i> .....	143

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>

International Frequency Sensor Association (IFSA).



International Frequency Sensor Association (IFSA) Publishing

## Digital Sensors and Sensor Systems: Practical Design

Sergey Y. Yurish



The goal of this book is to help the practitioners achieve the best metrological and technical performances of digital sensors and sensor systems at low cost, and significantly to reduce time-to-market. It should be also useful for students, lectures and professors to provide a solid background of the novel concepts and design approach.

### Book features include:

- Each of chapter can be used independently and contains its own detailed list of references
- Easy-to-repeat experiments
- Practical orientation
- Dozens examples of various complete sensors and sensor systems for physical and chemical, electrical and non-electrical values
- Detailed description of technology driven and coming alternative to the ADC a frequency (time)-to-digital conversion

Formats: printable pdf (Acrobat) and print (hardcover), 419 pages

ISBN: 978-84-616-0652-8,  
e-ISBN: 978-84-615-6957-1

*Digital Sensors and Sensor Systems: Practical Design* will greatly benefit undergraduate and at PhD students, engineers, scientists and researchers in both industry and academia. It is especially suited as a reference guide for practitioners, working for Original Equipment Manufacturers (OEM) electronics market (electronics/hardware), sensor industry, and using commercial-off-the-shelf components

[http://sensorsportal.com/HTML/BOOKSTORE/Digital\\_Sensors.htm](http://sensorsportal.com/HTML/BOOKSTORE/Digital_Sensors.htm)



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>

## An Intelligent Temperature Measurement Technique Using J Type Thermocouple with an Optimal Neural Network

**Santhosh K. V., B. K. Roy**

Department of Electrical Engineering

National Institute of Technology, Silchar

E-mail: kv.santhu@gmail.com, bkr\_nits@yahoo.co.in

*Received: 22 February 2012 /Accepted: 18 December 2012 /Published: 31 December 2012*

---

**Abstract:** This paper aims at designing an intelligent temperature measurement technique using J type thermocouple with an optimized neural network model. The objectives of this work are to (i) extend the linearity range of measurement to 100 % of the full scale, (ii) make the measurement system adaptive of variation in temperature coefficients and (iii) to achieve (i) and (ii) using optimal neural network. The output of thermocouple is in mV range. A suitable data conversion circuit is used to convert mV to voltage and to overcome the problem of interference of noise and open thermocouple detection. A suitable optimal Artificial Neural Network (ANN) block is added in cascade to data conversion unit. This arrangement helps to linearise the overall system and make it adaptive of variations in temperature coefficients. Since, the proposed intelligent temperature measurement technique produces adaptive of variation in physical properties of thermocouple. It avoids the requirement of repeated calibrations every time the thermocouple is replaced. Simulation results show that proposed measurement technique satisfies the objectives. *Copyright © 2012 IFSA.*

**Keywords:** Artificial neural networks, Thermocouple, Sensor modelling.

---

### 1. Introduction

Attempts of standardized temperature measurement have been reported as early as 170 AD by Claudius Galenus. The modern scientific field has its origins in the works by Florentine scientists in the 17<sup>th</sup> century. Temperature is one of the most frequently used process measurements. Almost all chemical processes and reactions are temperature dependent. In chemical plants, temperature is frequently the only indication of the progress of a process. Where the temperature is critical to the

reaction, a considerable loss of product may result from incorrect measurement of temperatures. In some cases, loss of control of temperature can result in catastrophic plant failure with consequent damages and possible loss of life. There are many other areas of industry in which temperature measurement is essential. Such applications include steam raising and electricity generation, plastics manufacture and moulding, milk and dairy products, and many other areas of the food industries. Thus, an accurate and precise measurement of temperature is very important.

Many methods have been developed for measuring temperature. Most of these rely on measuring some physical property of a working material that varies with temperature. Thermocouple is one such sensor which finds a wide application in a process industry because of its characteristics like accuracy and precision. However in the thermocouple the problem of non linearity has restricted its applications. To solve the problem of linearizing a sensor, there are in general two methods, the first one requires nonlinear analog circuit and the second uses numerical methods that are computed by microprocessor or personal computer [1]. The first method has a few practical drawbacks. Further, the whole circuitry may be altered or replaced when there is need to change thermocouple to achieve wide range, different sensitivity, cost etc. This increases the time and effective cost of the instrument. The last method is preferred because computer is used today for data acquisition and also it has the advantage of linearization on taking into account the effect of disturbing variables.

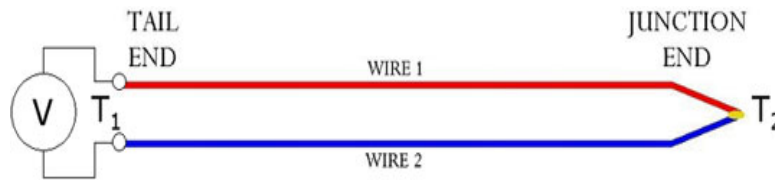
Artificial neural networks are broadly useful in a wide range of applications such as signal and image processing, pattern recognition [2], control systems [3] and recently instrumentation [4]. Because of their nonlinear characteristics, they are very useful in solving complex problems more accurately than linear techniques. So a method has been proposed in this paper using the concept of ANN. The ANN model is added in cascade to an amplifier circuit which will be trained to produce the linear relation between the input temperature and output of ANN. Further it's also made intelligent so as to produce results adaptive of the variation in physical parameters of the thermocouple so that no action is to be taken even though there is a change in thermocouple.

Literature survey reveals that linearization of temperature measurement using thermocouple has been attempted by many researchers using various techniques. Neural networks are used for this purpose by [5-7]. Linearization is achieved by analog circuits in [8, 9]. Linearization of level measurement using capacitance level sensor and making it independent of permittivity of the measuring liquid is discussed in [10]. Temperature measurement is presented in [11] using thermistor. Linearization of such temperature measurement and making it independent of temperature coefficient  $s$  of thermistor is reported.

The paper is organized as follows: after introduction in Section-1, a brief description on thermocouple is given in Section-2. The output of the thermocouple is mV; a brief discussion on signal conditioning unit i.e. an amplifier and compensator is discussed in Section-3. Section-4 deals with the problem statement followed by proposed solution in Section-5. Finally, result and conclusion is given in Section-6.

## **2. Thermocouple**

A thermocouple is a temperature-voltage transducer. It is a device made by two different wires joined at one end, called junction end or measuring end. The two wires are called thermo elements or legs of the thermocouple. The two thermo elements are distinguished as positive and negative ones. The other end of the thermocouple is called tail end or reference end as shown in Fig. 1. The junction end is immersed in the environment whose temperature  $T_2$  is to be measured, while the tail end is held at a different temperature  $T_1$ .



**Fig. 1.** Schematic diagram of a thermocouple.

Because of the difference in temperature between junction end and tail end, a voltage is measured between two thermo elements at tail end.

Approximately 300 different types of temperature measuring thermocouples have been identified and studied [12]-[14]. But, only a few types having the more favorable characteristics are used in general. There are eight types of thermocouples that have been standardized. Table 1 shows the list of standard thermocouples with its materials and ranges.

**Table. 1.** Types of standard thermocouple

No.	Type	Materials	Typical Range °C
1.	T	Copper (Cu) vs. Constantan	-270 to 400
2.	J	Iron (Fe) vs. Constantan	-210 to 1200
3.	K	Chromel vs. Alumel	-270 to 1370
4.	E	Chromel vs. Constantan	-270 to 1000
5.	S	(Pt-10%Rh) vs. Pt	-50 to 1768
6.	B	(Pt-13% Rh) vs. (Pt-6% Rh)	0 to 1820
7.	R	(Pt-13%Rh) vs. Pt	-50 to 1768
8.	N	(Ni-Cr-Si) vs. (Ni-Si-Mg)	-270 to 1300

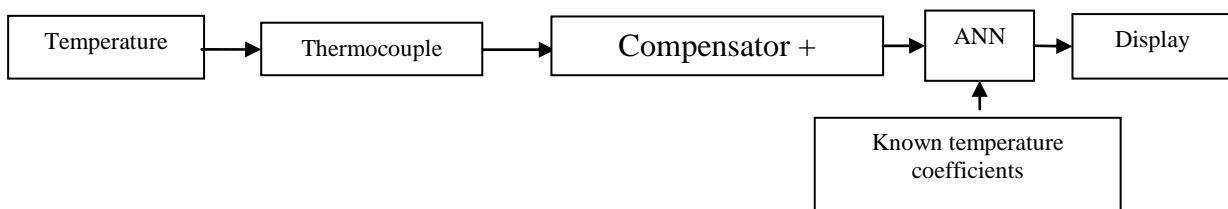
Equation 1 illustrates the power series model used for J type thermocouples [5, 6]

$$V = C_1(T_2 - T_1) + C_2((T_2 - 273)^2 - (T_1 - 273)^2) \mu V, \quad (1)$$

where:  $T_2$  – Hot junction temperature of thermocouple in °C;  
 $T_1$  – Cold junction temperature of thermocouple in °C;  
 $C_1$  &  $C_2$  – Coefficients depending on the materials used.

### 3. Data Conversion Unit

The block diagram representation of the proposed measurement technique is given in Fig. 2.

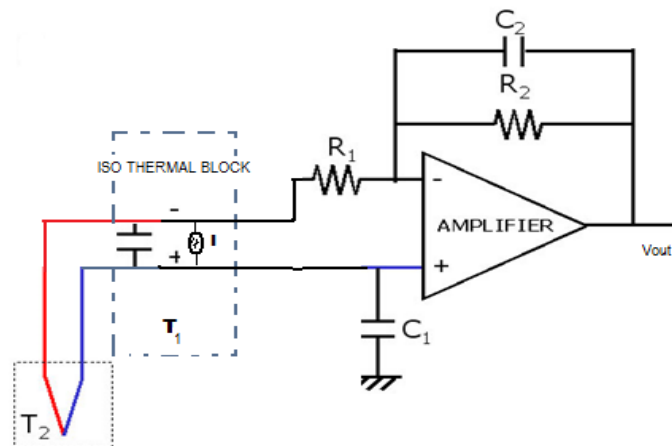


**Fig. 2.** Block diagram of the proposed temperature measurement technique.

### 3.1. Compensator and Amplifier

The tail end is maintained at ambient temperature by cold junction compensator. The temperature fluctuations between two legs at the tail end are tolerated. Thermocouple produces a voltage proportional to  $(T_2 - T_1)$  and hence the voltage proportional to  $T_2$  is not generated. An additional voltage equal to the voltage produced by thermocouple for the temperature difference of  $0^\circ\text{C}$  to  $T^\circ\text{C}$  is added with the voltage at tail end so that the total voltage is proportional to  $T_2^\circ\text{C}$ . [12-15].

A sketch of a thermocouple with cold junction compensation is shown in Fig. 3.



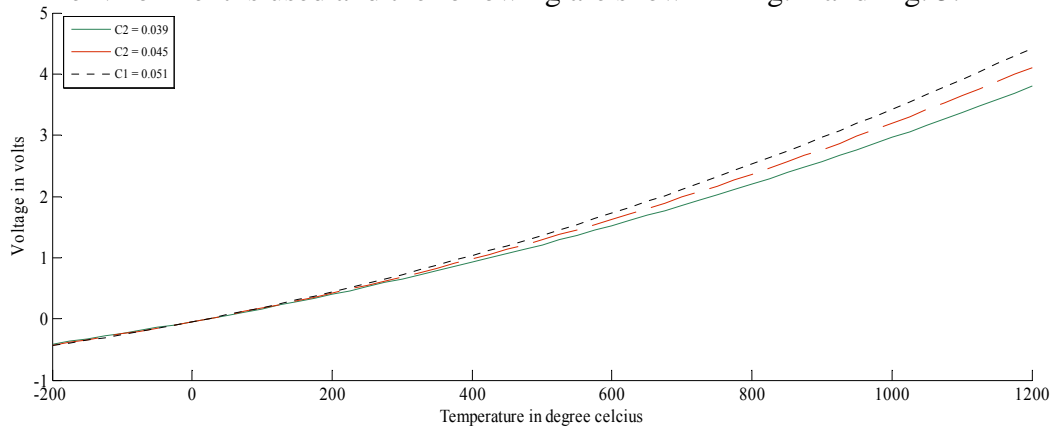
**Fig. 3.** A Cold Junction Compensation circuit.

The output of thermocouple ranges in the mV. Which make it very difficult to handle such signal. So, an amplifier is used to amplify the signal as shown in Fig. 3. The ratio of  $R_2$  and  $R_1$  will decide the amplification factor. Because thermocouples generate a relatively small voltage, noise is always an issue. The most common source of noise is the utility power lines (50 or 60 Hz). Thermocouple bandwidth is lower than 50 Hz, so a simple filter in each channel can reduce the interfering ac line noise. Common filters include resistors and capacitors and active filters built around op amps. Detecting open thermocouples easily and quickly is especially critical in systems with numerous channels. Thermocouples tend to break or increase in resistance when exposed to vibration, poor handling, and long service time. A simple open thermocouple detection circuit comprises a small capacitor placed across the thermocouple leads and driven with a low level current. The low impedance of the intact thermocouple presents a virtual short circuit across the capacitor so it cannot charge. But when a thermocouple opens or significantly changes resistance, the capacitor charges and drives the input to one of the voltage rails, which positively indicates a defective thermocouple.

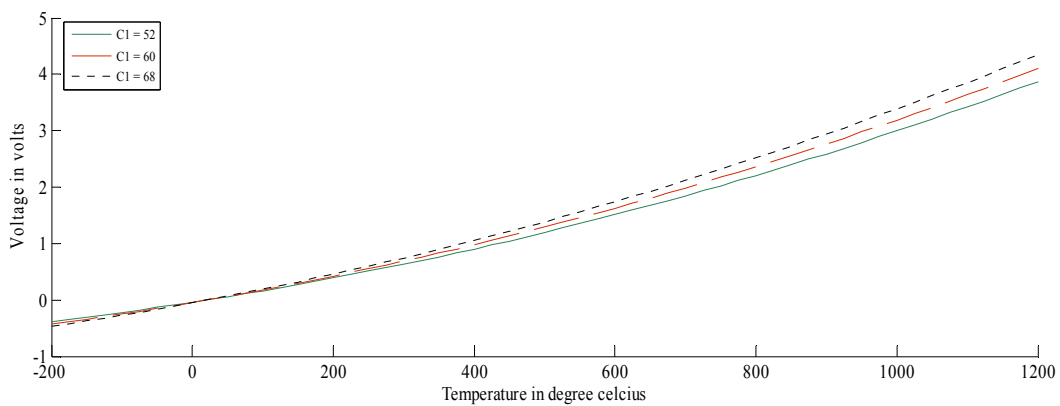
### 4. Problem Statement

In this section characteristics of thermocouple are simulated to understand the difficulties associated with the available measurement technique. For this purpose, simulation is carried out using J type thermocouple. The equation (1) is used to find the output voltage of thermocouple with respect to various values of input temperatures considering a particular value of temperature coefficients. These output voltages are used as input to compensator and amplifier circuit and the final voltage is produced.

The MATLAB environment is used and the following are shown in Fig. 4 and Fig. 5.



**Fig. 4.** Data converter outputs for variation of temperature with  $C_2$  and  $C_1 = 60$ .



**Fig. 5.** Data converter outputs for variation of temperature with  $C_1$  and  $C_2 = 0.045$ .

Fig. 4 and Fig. 5 show the variation of voltage with the change in input temperature for different values of coefficients.

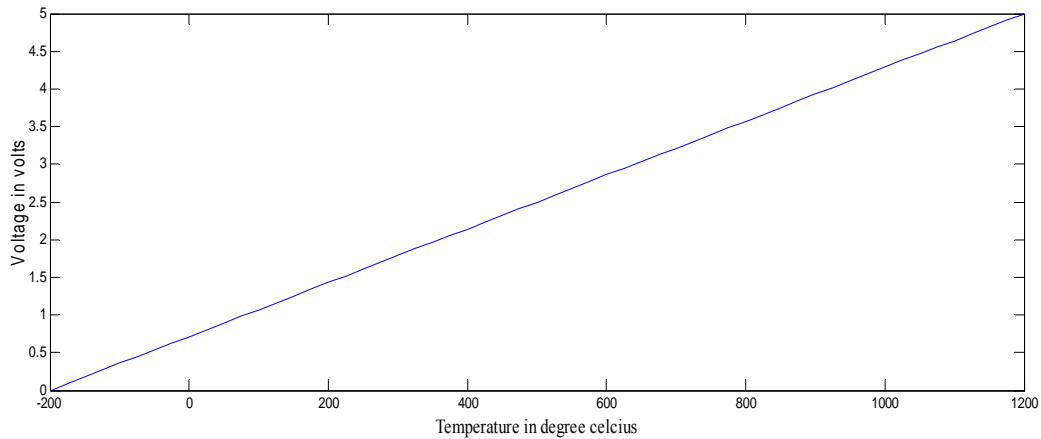
It has been observed from the above graphs (Fig. 4 and Fig. 5) that the output from the data converter circuit has a non linear relation. Datasheet of thermocouple suggests that the input range of 10 % to 70% of full scale is used in practice as linear range. The output voltage also varies with the changes in coefficients. These are the reasons which have made the user to go for calibration techniques using some circuits. The conventional techniques have a drawback that its time consuming and need to be calibrated every time a thermocouple is replaced in the system. Further, the use is restricted only to a portion of full scale.

To overcome these drawbacks, this paper makes an attempt to design a temperature measurement technique incorporating intelligence to produce linear output and to make the system adaptive of variations in temperature coefficients using a suitable optimized artificial neural network.

## 5. Problem Solution

The drawbacks discussed in the earlier section are overcome by introducing an optimized ANN model is cascaded after data converter unit. This model is designed using the neural network toolbox of MATLAB.

The first step in developing a neural network is to create a database. The output voltage of the system for a particular change in temperature and coefficients  $C_1$  and  $C_2$  is stored as row of input data matrix various such combinations of input temperature,  $C_1$ ,  $C_2$  and their corresponding output voltages are used to form the other rows of input data matrix. The output matrix would be the target matrix consisting of data having a linear relation with the temperature and adaptive of variation in  $C_1$  and  $C_2$  all other parameters as shown in Fig. 6.



**Fig. 6.** Target graph for ANN.

## 5.1. Training

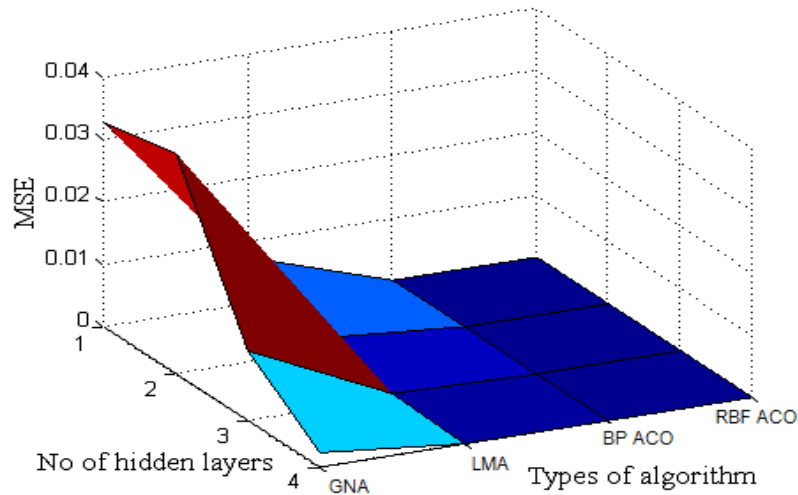
The process of finding the weights to achieve the desire output is called training. The optimized ANN is found by considering different algorithms with varying hidden layer as shown in Table. 2. Mean Squared Error (MSE) is the average squared difference between outputs and targets. Lower values of MSE are better. Zero means no error. Regression (R) measure the correlation between output and target. Regression equal to 1 means a close relationship and 0 means a random relationship. With these details the network is trained to achieve its desired target. The details of the neural network are given in Table 2.

**Table. 2.** Comparison of Algorithm and Hidden layers.

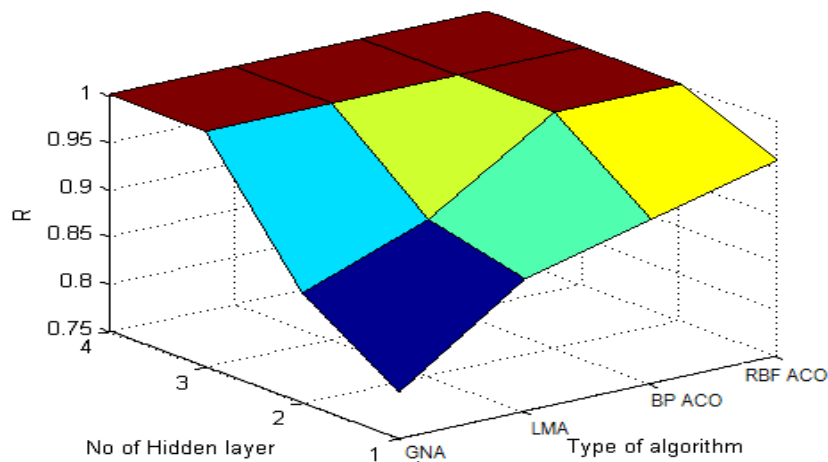
Hidden layers		GNA	LMA	BP trained by ACO	RBF trained by ACO
1.	MSE	3.256E-2	3.516E-2	1.11E-2	2.325E-3
	R	0.7992	0.889999	0.92353	0.9568
2.	MSE	7.3658E-3	1.986E-3	5.83E-4	3.658E-5
	R	0.8659512	0.91456	0.99875	0.9992
3.	MSE	3.465E-5	9.264E-5	1.32E-6	3.658E-7
	R	0.998856	0.9994513	0.9999235	0.99998265
4.	MSE	6.78E-7	2.585E-7	1.993E-9	6.847E-10
	R	0.9999321	0.999992	0.99999940	0.999999

Four different schemes and algorithms are used to find the optimized ANN. These are Gauss-Newton Algorithm (GNA) [16, 17], Levenberg-Marquardt algorithm (LMA) [16, 18], Back Propagation neural network (BP) trained by Ant Colony Optimization (ACO) [19-21] and Radial Basis Function (RBF)

trained by ACO [22-24]. Training of ANN is first done assuming only one hidden layer. MSE and R values are noted. Hidden layer is increased to 2 and training is repeated. This process is continued up to 4 hidden layers. In all cases MSE and R are noted and shown in Table 2. MSE's and R's corresponding to different algorithm and hidden layers are shown in Fig. 7 and Fig. 8. From Table 2, Fig. 7 and Fig. 8 its very clear that RBF trained by ACO yields most accurate results. RBF trained by ACO with 3 layers is considered as the most optimized ANN for better accuracy of result.



**Fig. 7.** Graph showing the MSE corresponding to different ANN models.



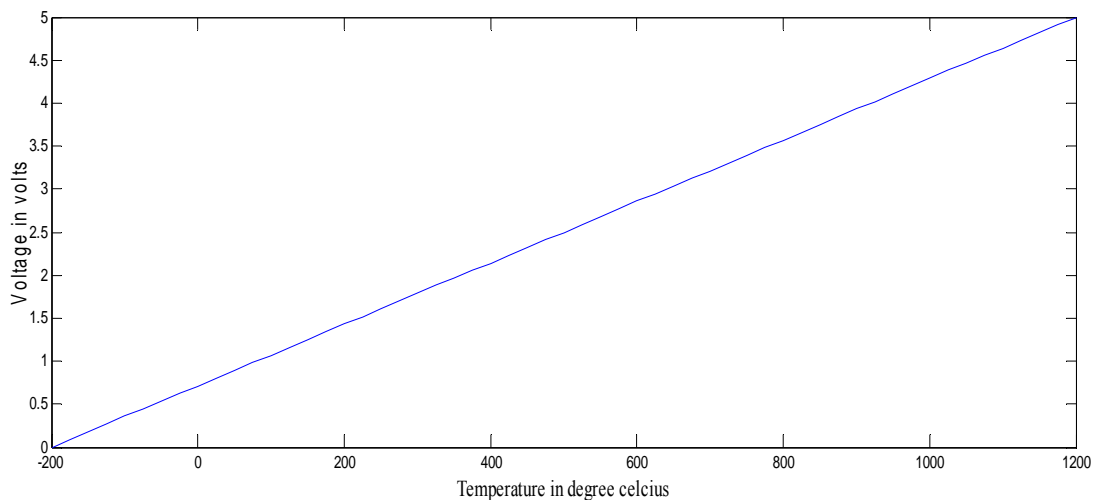
**Fig. 8.** Graph showing the R corresponding to different ANN models.

## 6. Result and Conclusion

As discussed, ANN is trained, validated and tested with simulated data. Once the training is over, the proposed measurement system as shown in Fig. 2 is subjected to various test inputs corresponding to different combinations of temperature,  $C_1$  and  $C_2$ , all within the range given in Table. 3. For testing purposes the range of temperature is considered from  $-210\text{ }^\circ\text{C}$  (63 K) to  $1200\text{ }^\circ\text{C}$  (1473 K). The range of coefficient  $C_1$  is 50 to 70 and range of coefficient  $C_2$  is 0.039 to 0.051. The output voltages and of system are noted corresponding to various combination of input temperature coefficients  $C_1$  and  $C_2$ , within the range. The input temperatures and the corresponding output voltages are plotted and are shown in Fig. 9. The output graph is matching the target graph as shown in Fig. 6.

**Table 3.** Summarizes the require data for training.

Optimized parameters of the neural networks model				
Database		Training base (70 %)		98
		Validation base (15 %)		21
		Test base (15 %)		21
No of neurons in		1 <sup>st</sup> layer		7
		2 <sup>nd</sup> layer		7
		3 <sup>rd</sup> layer		8
Transfer function of		1 <sup>st</sup> layer		tansig
		2 <sup>nd</sup> layer		tansig
		3 <sup>rd</sup> layer		tansig
		Output layer		linear
Input		Temperature	$C_1$	$C_2$
	min	-210 °C (63 K)	50	0.039
	max	1200 °C (1473 K)	70	0.051

**Fig. 9.** Response of the system for change in temperature and temperature within the range.

It is evident from the Fig. 9, that the proposed measurement technique has incorporated intelligence to the thermocouple. It has increased the linearity range of the thermocouple to 100 % of full scale of input range and the output is made adaptive of variation in coefficients  $C_1$  and  $C_2$ . Thus if a thermocouple is replaced by another having different values of temperature coefficients, the proposed measurement technique does not require any calibration.

Available reported works have discussed different techniques used for calibration of thermocouple, but these are not adaptive of variations in temperature coefficients. Hence, repeated calibration is requested for any change of thermocouple. Some time the calibration circuit may itself be replaced which is a time consuming and tedious procedure. Further, some reported works don't utilize the full scale of measurement. In comparison to these, the proposed measuring technique achieves linear input output characteristics for full input range and also makes the output adaptive of variations in the coefficients. So, proposed technique avoids repeated calibration every time a thermocouple is replaced. An optimized ANN is used by comparing various scheme, algorithms and hidden layers to achieve the objectives in comparison to an arbitrary ANN in most of the reported works. Similarly technique may be incorporated for other different types of thermocouples.

## References

- [1]. M. Attari, Methods For Linearization of Non-Linear Sensors, *Proc. of the 4<sup>th</sup> Maghreb Conference on Numerical Methods of Engineering, CMMNI-4*, Algiers (Algeria), Vol. 1, pp. 344-350, November 1993.
- [2]. J. A. Freeman, *Neural Networks: Algorithms, Applications, and Programming Techniques*, Addison-Wesley, Massachusetts, 1992.
- [3]. M. E. Aggoune, F. Boudjema, A. Bensenouci, A. Hellal, S. V. Vadari, M. R. El Mesai, Design of an adaptive-structure voltage regulator using artificial neural networks, in *Proc. of the 2<sup>nd</sup> IEEE Conference on Control Applications*, Vancouver, Canada, September 1993, pp. 337-343.
- [4]. L. F. Pau and F. S. Johansen, Neural Network Signal Understanding for Instrumentation, *IEEE Transactions on Instrumentation & Measurement*, Vol. 39, No. 4, Aug. 1990, pp. 558-564.
- [5]. Dia wen, Lin Qing, Lu Qiang, Calibration system of thermocouple application based on technology of virtual instrument and neural network, in *Proc. of the IEEE Conference on Electronic Measurements and Instruments*, 2007, pp. 268-273.
- [6]. N J Medrano-Marques, B Martin-del-Brio, A General Method for Sensor Linearization based on Neural Networks, in *Proc. of the IEEE International Symposium on Circuits and Systems*, Geneva, Switzerland, May 2000.
- [7]. Guo Li-Hui, Wang Wu, Jiao Xiao-Bo, Thermocouple signal conditioning with genetic optimizing RBF neural networks, in *Proc. of the IEEE Conference on Communication Software and Networks*, Xian 2011.
- [8]. Jim Williams, *Thermocouple Measurement*, Linear Technology, Application note no 28, 1998.
- [9]. J. Francis, T. M. Yau, On Radiant Network Models of Thermocouple Error in Pre and Past Flashover Compartment Fires, *Journal on Fire Technology*, Vol. 40, 2004, pp. 277-294.
- [10]. B. K. Roy, Santhosh K. V., An Intelligent Instrument for Measuring Liquid Level, in *Proc. of the IEEE Conference Process Automation Control and Computing (PACC' 2011)*, Coimbatore, India, July 2011.
- [11]. Santhosh K V, B K Roy, A Smart Temperature Measuring Technique Using Thermistor, *International Journal of Engineering Science and Management*, Vol. I, No 2, 2011.
- [12]. Kinzie, P. A., *Thermocouple Temperature Measurement*, John Wiley Publication, New York, 1973.
- [13]. Bela G. Liptak, *Instrument Engineers Handbook-Process Measurement and Analysis*, 4<sup>th</sup> Edition, CRC Press, 2003.
- [14]. John P. Bentley, *Principle of Measurement Systems*, 3<sup>rd</sup> Edition, Pearson Education Publication, India, 2003.
- [15]. Ramon Pallas-Areny, John G. Webster, *Sensors and Signal Conditioning*, 2<sup>nd</sup> Edition, A Wiley-Interscience Publication, 2001.
- [16]. Björck A., *Numerical methods for least squares problems*, SIAM Publications, Philadelphia, 1996.
- [17]. Fletcher, Roger, *Practical methods of optimization*, 2<sup>nd</sup> Edition, John Wiley & Sons, New York, 1987.
- [18]. Fernando Morgado Dias, Ana Antunes, José Vieira, Alexandre Manuel Mota, Implementing the Levenberg-Marquardt Algorithm on-line: a sliding window approach with early stopping, in *Proc. of the Int. Conf. Proc. IFAC*, USA, 2004.
- [19]. Jeng-Bin Li, Yun-Kung Chung, A Novel Back propagation Neural Network Training Algorithm Designed by an Ant Colony Optimization, in *Proc. of the IEEE/PES Transmission and Distribution Conference & Exhibition: Asia and Pacific Dalian*, China, 2005.
- [20]. L. Bianchi, L. M. Gambardella, M. Dorigo, An ant colony optimization approach to the probabilistic travelling salesman problem, in *Proc. of the 7<sup>th</sup> International Conference on Parallel Problem Solving from Nature PPSN-VII*, Berlin, Germany, 2002.
- [21]. Stuart Russell and Peter Norvig, *Artificial Intelligence A Modern Approach*, 3<sup>rd</sup> Edition, Prentice Hall, New York, 2009.
- [22]. Park J., Sandberg J. W., Universal Approach Using Radial Basis Function Network, *Neural Computation*, Vol. 3, 1991, pp. 246-257.
- [23]. T. Poggio, F. Girosi, Networks for approximation and learning, *Proc. IEEE*, 78, 9, 1990, pp. 1484-1487.
- [24]. Paul Yee V and Simon Haykin, *Regularized Radial Basis Function Networks: Theory and Applications*, John Wiley, 2001.



# International Frequency Sensor Association Publishing Call for Books Proposals

Sensors, MEMS, Measuring instrumentation, etc.



## Benefits and rewards of being an IFSA author:

1

### Royalties

Today IFSA offers most high royalty in the world: you will receive 50 % of each book sold in comparison with 8-11 % from other publishers, and get payment on monthly basis compared with other publishers' yearly basis.

2

### Quick Publication

IFSA recognizes the value to our customers of timely information, so we produce your book quickly: 2 months publishing schedule compared with other publishers' 5-18-month schedule.

3

### The Best Targeted Marketing and Promotion

As a leading online publisher in sensors related fields, IFSA and its Sensors Web Portal has a great expertise and experience to market and promote your book worldwide. An extensive marketing plan will be developed for each new book, including intensive promotions in IFSA's media: journal, magazine, newsletter and online bookstore at Sensors Web Portal.

4

### Published Format: printable pdf (Acrobat).

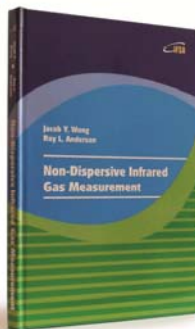
When you publish with IFSA your book will never go out of print and can be delivered to customers in a few minutes.

You are invited kindly to share in the benefits of being an IFSA author and to submit your book proposal or/and a sample chapter for review by e-mail to [editor@sensorsportal.com](mailto:editor@sensorsportal.com). These proposals may include technical references, application engineering handbooks, monographs, guides and textbooks. Also edited survey books, state-of-the art or state-of-the-technology, are of interest to us. For more detail please visit: [http://www.sensorsportal.com/HTML/IFSA\\_Publishing.htm](http://www.sensorsportal.com/HTML/IFSA_Publishing.htm)



## International Frequency Sensor Association (IFSA) Publishing

NEW BOOK



Formats: printable pdf (Acrobat) and print (hardcover), 120 pages

ISBN: 978-84-615-9732-1,  
e-ISBN: 978-84-615-9512-9

**Jacob Y. Wong, Roy L. Anderson**

### **Non-Dispersive Infrared Gas Measurement**

Written by experts in the field, the *Non-Dispersive Infrared Gas Measurement* begins with a brief survey of various gas measurement techniques and continues with fundamental aspects and cutting-edge progress in NDIR gas sensors in their historical development.

- It addresses various fields, including:
- Interactive and non-interactive gas sensors
- Non-dispersive infrared gas sensors' components
- Single- and Double beam designs
- Historical background and today's of NDIR gas measurements

Providing sufficient background information and details, the book *Non-Dispersive Infrared Gas Measurement* is an excellent resource for advanced level undergraduate and graduate students as well as researchers, instrumentation engineers, applied physicists, chemists, material scientists in gas, chemical, biological, and medical sensors to have a comprehensive understanding of the development of non-dispersive infrared gas sensors and the trends for the future investigation.

[http://sensorsportal.com/HTML/BOOKSTORE/NDIR\\_Gas\\_Measurement.htm](http://sensorsportal.com/HTML/BOOKSTORE/NDIR_Gas_Measurement.htm)

## 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 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. 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

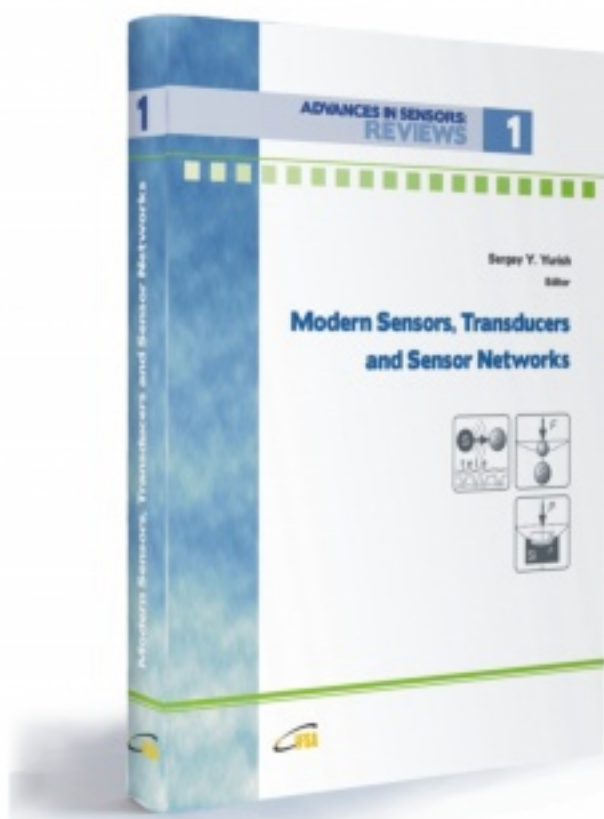
Articles should be written in English. Authors are invited to submit by e-mail [editor@sensorsportal.com](mailto:editor@sensorsportal.com) 8-14 pages article (including abstract, illustrations (color or grayscale), photos and references) in both: MS Word (doc) and Acrobat (pdf) formats. Detailed preparation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

### Advertising Information

Advertising orders and enquires may be sent to [sales@sensorsportal.com](mailto:sales@sensorsportal.com) Please download also our media kit: [http://www.sensorsportal.com/DOWNLOADS/Media\\_Kit\\_2012.pdf](http://www.sensorsportal.com/DOWNLOADS/Media_Kit_2012.pdf)

**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](http://sensorsportal.com/HTML/BOOKSTORE/Advance_in_Sensors.htm)



[www.sensorsportal.com](http://www.sensorsportal.com)