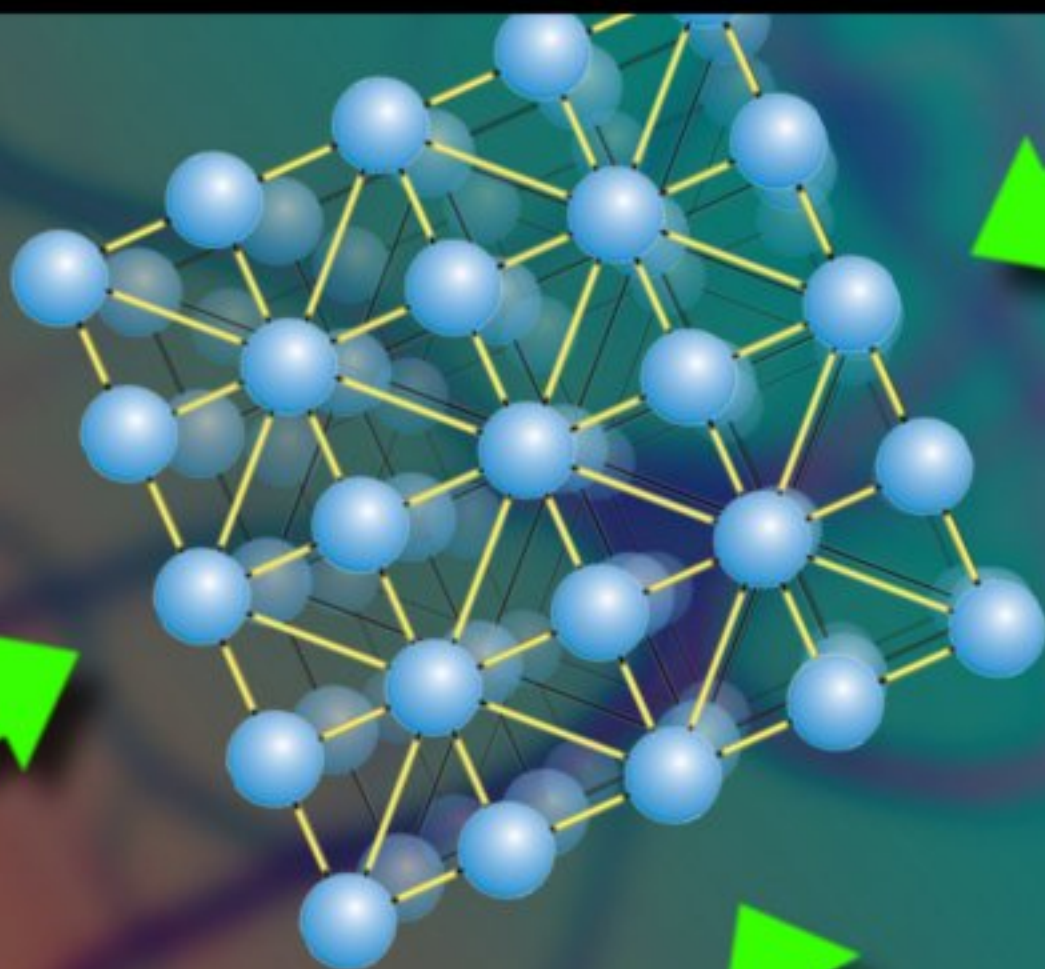


ISSN 1726-5479

SENSORS **10** ^{vol. 145} / **12** **&** **TRANSDUCERS**



Soft Sensors and Artificial Neural Networks

International Frequency Sensor Association Publishing



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, 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, Vyngantas, 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, 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
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, 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
Diegues, 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, 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
Driljaca, 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
Grael, 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
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
Kotulski, 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, Nezhil, 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 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
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
Raoof, 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 Politecnica de Catalunya, Spain
Rodriguez, Angel, Universidad Politecnica de Cataluna, 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, Selemeni, Alabama A & M University, USA
Seifter, Achim, Los Alamos National Laboratory, USA
Shah, Kriyang, La Trobe University, Australia
Sankarraj, Anand, Detector Electronics Corp., 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
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 Shiyong 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 145
Issue 10
October 2012

www.sensorsportal.com

ISSN 1726-5479

Research Articles

Implementation of ANN in FPGA for improved Temperature Drift of the MEMS Flow Sensor <i>I. Mellal, M. Laghrouche, B. Idjeri, R. Beguenane, S. Ameer</i>	1
Modeling and Control of Smart Structure Using Soft Computing Method <i>M. Sridevi, P. Madhavasarma, P. Prakasam</i>	10
Identifying Convective and Stratiform Rain by Confronting SEVERI Sensor Multispectral Infrared to Radar Sensor Data Using Neural Network <i>M. Lazri, F. Oualloche, S. Ameer, J. M. Brucker and Y. Mohia</i>	19
Design of Float-Image Level Transmitter for Level Measurement Using Image Processing Technique <i>N. S. Abinaya and S. Rakesh Kumar</i>	33
Model Identification and control of Non Linear Spherical Tank Process using Soft Computing Method <i>M.Sridevi, P. Madhavasarma, P. Prakasam</i>	41
Measure of the Conductivity by Electromagnetic Inductive Sensor <i>Rouane Amar</i>	50
Authentication of Indian Wines Using Voltammetric Electronic Tongue Coupled with Artificial Neural Networks <i>Hepsiba K. Anga, P. C. Panchariya and A. L. Sharma</i>	65
Non Destructive Classification of Himalayan Orthodox Black Teas <i>S. Kumar, P. C. Panchariya, Bhanu Prasad P. and A. L. Sharma</i>	77
A Piezoresistive Acceleration Sensor: from System to Physical Levels <i>Tran Duc Tan</i>	86
Recent Advance in Plantar Pressure Measurement Systems <i>Yemin Guo, Lanmei Wang</i>	96
The Classification of Scores from Multi-classifiers for Face Verification <i>Abdelmalik Ouamane, Mébarka Belahcene, Abdelhamid Benakcha, Mohamed Boumehrez, Abdelmalik Taleb Ahmed</i>	106
A Calibration Method of Binocular Vision System for Large Forging Dimension Measurement <i>Wei Liu, Xin Ma, Zhenyuan Jia, Wenqiang Wang and Yang Zhang</i>	119
Quality Inspection of Parenteral Vials Using Digital Image Analysis <i>S. Deena Christilda, M. Prathiba, P. Neelamegam</i>	130

High-Speed Fastener Detection System Based on Machine Vision <i>Jinfeng Yang, Wei Tao, Chunfeng Lü, Yongjie Zhang, Hui Zhao</i>	138
Bio Inspired Algorithm for PID Controller Tuning and Application to the Pulp and Paper Industry <i>B. Nagaraj, P. Vijayakumar</i>	149
Design of Adaptive PID Controller Based on Maximum Modulus Theorem for Inverted Pendulum on a Cart <i>Jim George, Bipin Krishna, V. I. George, Mukund Kumar Menon.....</i>	163
New Load Balancing Algorithm for LEACH Protocol (F-VCH LEACH) <i>Muneer Bani Yassein, Zeinab Jaradat, Neveen Hijazi, Constandinos Mavromoustakis.</i>	172
Efficient Implementation of FPGA Based PID Control Algorithm for Temperature Control System <i>M. A. Majed and Prof. C. S. Khandelwal.....</i>	183
Performance Comparison of PCA and ICA Pre-processors in Identification of Individual Gases Using Response of a Poorly Selective Solid-state Sensor Array <i>Akash Agrawal, Ravi Kumar, Amit Kumar Kohli, R. Dwivedi</i>	191

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



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>

Design of Adaptive PID Controller Based on Maximum Modulus Theorem for Inverted Pendulum on a Cart

Jim George, Bipin Krishna, V. I. George, Mukund Kumar Menon

Department of Instrumentation and Control, Manipal Institute of Technology,
Manipal, Karnataka-576104, India

E-mail: jimchiramattel@yahoo.com, bipinskrishna@yahoo.co.in, vi.george@manipal.edu,
mukundettan@gmail.com

Received: 20 June 2012 /Accepted: 22 October 2012 /Published: 31 October 2012

Abstract: Stabilization of a pendulum in inverted position when the base is moving is one of the challenging tasks in aircraft, automobile and ship industries. So in this paper the system under consideration is inverted pendulum on a cart which has single degree of freedom (angular rotation of pendulum). In industries depending upon the variation in operating conditions controller have to be tuned accordingly. That is depending upon the desired conditions, controller parameters should have flexibility i.e. the principle of adaptive control. This paper in brief discuss about design of a tuning parameter based on Maximum Modulus Theorem so that the required time domain specifications can be achieved. *Copyright © 2012 IFSA.*

Keywords: Inverted pendulum on cart, Maximum Modulus Theorem, Tuning parameter, PID Controller, Time domain specifications.

1. Introduction

An Inverted Pendulum on a Cart consists of a pendulum which is attached to the cart (moving base pendulum). The aim of this paper is to design adaptive PID controller based on Maximum Modulus Theorem.

The system inverted pendulum on a cart is considered as a single input single output (SISO) system with force applied to the cart as input and the angular displacement of the pendulum as output.

The only assumption taken is friction is negligible.

2. Inverted Pendulum on a Cart

An inverted pendulum is a pendulum which has its mass above its pivot point (Fig.). It is often implemented with the pivot point mounted on a cart that can move horizontally and may be called a cart and pole. Whereas a normal pendulum is stable when hanging downwards, an inverted pendulum is inherently unstable, and must be actively balanced in order to remain upright, either by applying a torque at the pivot point or by moving the pivot point horizontally as part of a feedback system. A simple demonstration is achieved by balancing an upturned broomstick on the end of one's finger.

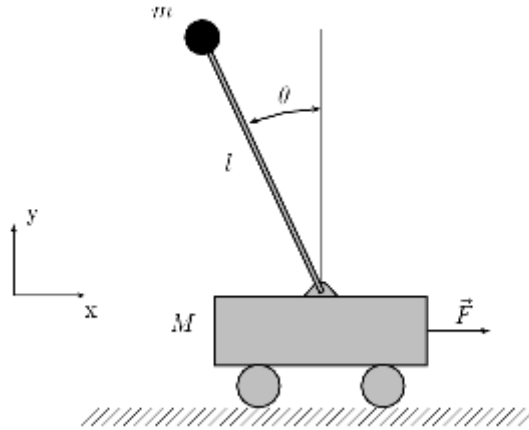


Fig. 1. Inverted Pendulum on a moving cart.

3. System Modeling

The equations of motion can be derived using Lagrange's equations. We refer to the drawing above where $\Theta(t)$ is the angle of the pendulum of length l with respect to the vertical direction and the acting forces are gravity and an external force F in the x -direction. Define $x(t)$ to be the position of the cart. Lagrangian (L) is given by difference between total Kinetic Energy and total Potential Energy.

$$L = KE_{Total} - PE_{Total} \quad (1)$$

$$L = \frac{1}{2}Mv_1^2 + \frac{1}{2}mv_2^2 - mg\ell \cos \theta \quad (2)$$

where v_1 is the velocity of the cart and v_2 is the velocity of the point mass m . v_1 and v_2 can be expressed in terms of x and θ by writing the velocity as the first derivative of the position:

$$v_1^2 = \dot{x}^2 \quad (3)$$

$$v_2^2 = \left(\frac{d}{dt}(x - \ell \sin \theta) \right)^2 + \left(\frac{d}{dt}(\ell \cos \theta) \right)^2 \quad (4)$$

Simplifying the expression for v_2 leads to:

$$\dot{v}_2^2 = \dot{x}^2 - 2\ell\dot{x}\dot{\theta}\cos\theta + \ell^2\dot{\theta}^2 \quad (5)$$

The Lagrangian is now given by:

$$L = \frac{1}{2}(M+m)\dot{x}^2 - m\ell\dot{x}\dot{\theta}\cos\theta + \frac{1}{2}m\ell^2\dot{\theta}^2 - mg\ell\cos\theta \quad (6)$$

and the equations of motion are:

$$\frac{d}{dt}\frac{\partial L}{\partial \dot{x}} - \frac{\partial L}{\partial x} = F \quad (7)$$

$$\frac{d}{dt}\frac{\partial L}{\partial \dot{\theta}} - \frac{\partial L}{\partial \theta} = 0 \quad (8)$$

substituting L in these equations and simplifying leads to the equations that describe the motion of the inverted pendulum:

$$(M+m)\ddot{x} - m\ell\ddot{\theta}\cos\theta + m\ell\dot{\theta}^2\sin\theta = F \quad (9)$$

$$\ell\ddot{\theta} - g\sin\theta = \ddot{x}\cos\theta \quad (10)$$

These equations are nonlinear, but since the goal of a control system would be to keep the pendulum upright the equations can be linearized around $\theta \approx 0$.

The transfer function of the system is obtained as:

$$\frac{\Theta(s)}{F(s)} = \frac{1}{s^2(\ell(M+m) - m\ell^2)} \quad (A)$$

The system is double integrating system having two poles at the origin of s plane which is a highly unstable system.

3. Design of Adaptive PID Controller based on Maximum Modulus Theorem

If the plant has a zero at right half of s- plane then the theorem states that:

$$\|W(1 - QP)\|_{\infty} \geq W\left(\frac{1}{s}\right), \quad (11)$$

where $s = \frac{1}{\theta}$ is the zero on the right half of s plane of the plant P, and W is the weighting function.

Minimizing the left hand side of the of the above equation, we get

$$\min \|W(1 - QP)\|_{\infty} = W\left(\frac{1}{s}\right) \quad (12)$$

Let us consider the plant

$$G(s) = \frac{ke^{-\theta s}}{s^2} \quad (13)$$

By Taylor series approximation $G(s)$ can be written as:

$$G(s) = \frac{k(1 - \theta s)}{s^2} \quad (14)$$

Solving equation (a) gives the optimal Q which is given by the expression:

$$Q_{\text{opt}}(s) = \frac{W(s) - \theta}{W(s)sG(s)} = \frac{s}{K} \quad (15)$$

So $Q(s)$ will result in an improper transfer function given by:

$$Q_{\text{im}}(s) = \frac{s^2}{K} \quad (16)$$

To implement the above transfer function, it should be cascaded with a low pass filter $J_c(s)$

Selection of $J_c(s)$:

$$\lim_{s \rightarrow 0} (1 - Q(s)F(s)) = 0 \quad (17)$$

s tends to zero means t tends to infinity (final value theorem), so that the process results in a constant output.

The process model

$$G(s) = \frac{ke^{-\theta s}}{s^2}$$

is a double integrator.

If a step disturbance is given to it, then it becomes equivalent to:

$$G(s) = \frac{ke^{-\theta s}}{s^2}$$

So the sensitivity function S should possess three zeros at the origin of s-plane. This rejects the disturbance which is injected at the process input side.

Therefore we select $J_c(s)$ as:

$$J_c(s) = \frac{as^2 + bs + 1}{(\lambda_c s + 1)^4}, \quad (18)$$

where ' λ_c ' is the tuning parameter.

By employing low pass filter, the suboptimal $Q(s)$ can be obtained as

$$Q(s) = Q_{\text{im}}(s)J_c(s) \quad (19)$$

To find a and b:

$$\lim_{s \rightarrow 0} \frac{d}{ds} (1 - QG) = 0 \quad (20)$$

$$\lim_{s \rightarrow 0} \frac{d}{ds} \left(1 - \frac{s^2(as^2 + bs + 1)}{k(\lambda_c s + 1)^2(1 - \theta s)} \right) = 0 \quad (21)$$

Solving the above equation, we get:

$$\begin{aligned} a &= 6\lambda_c^2 + 4\lambda_c + \theta^2 \\ b &= 4\lambda_c + \theta \end{aligned}$$

So Q(s) is obtained as in the form given below:

$$Q(s) = \frac{s^2((6\lambda_c^2 + 4\lambda_c + \theta^2)s^2 + (4\lambda_c + \theta)s + 1)}{k(\lambda_c s + 1)^4} \quad (22)$$

We have the general expression of Q as given below:

$$Q = \frac{C}{1 + PC} \quad (23)$$

So the controller C is given by:

$$C = \frac{Q}{1 - QP} \quad (24)$$

Substituting Q and P in C we obtain:

$$C(s) = \frac{1(6\lambda_c^2 + 4\lambda_c + \theta^2)s^2 + (4\lambda_c + \theta)s + 1}{k \lambda_c^4 s^2 + (4\lambda_c^2 + 6\lambda_c\theta + 4\lambda_c\theta^2 + \theta^2)s} \quad (25)$$

This is in the form of PID controller

$$C(s) = k_c \left(1 + \frac{1}{T_i s} + \frac{T_d s}{T_f s + 1} \right) \quad (26)$$

Comparing both the equations, we get

$$T_f = \frac{\lambda_c^4}{4\lambda_c^2 + 6\lambda_c\theta + 4\lambda_c\theta^2 + \theta^2} \quad (27)$$

$$T_d = \frac{6\lambda_c^2 + 4\lambda_c\theta + \theta^2}{T_i} - T_f \quad (28)$$

$$T_i = 4\lambda_c + \theta - T_f \quad (29)$$

$$k_c = \frac{T_i}{k(4\lambda_c^2 + 6\lambda_c\theta + 4\lambda_c\theta^2 + \theta^2)} \quad (30)$$

Let $l=1\text{m}$, $m=.5\text{ kg}$, $M=10\text{ kg}$,

Substituting in equation (A),

$$\frac{\Theta(s)}{F(s)} = \frac{.1}{s^2}$$

For this system time delay, $\Theta=0\text{ s}$.

Case 1. Let tuning parameter, $\lambda_c = 1$

So,

$$\begin{aligned} T_f &= .25 \\ T_i &= 3.75 \\ T_d &= 1.35 \\ k_c &= 9.375 \end{aligned}$$

The step response and stability can be shown as given in Fig. 2.

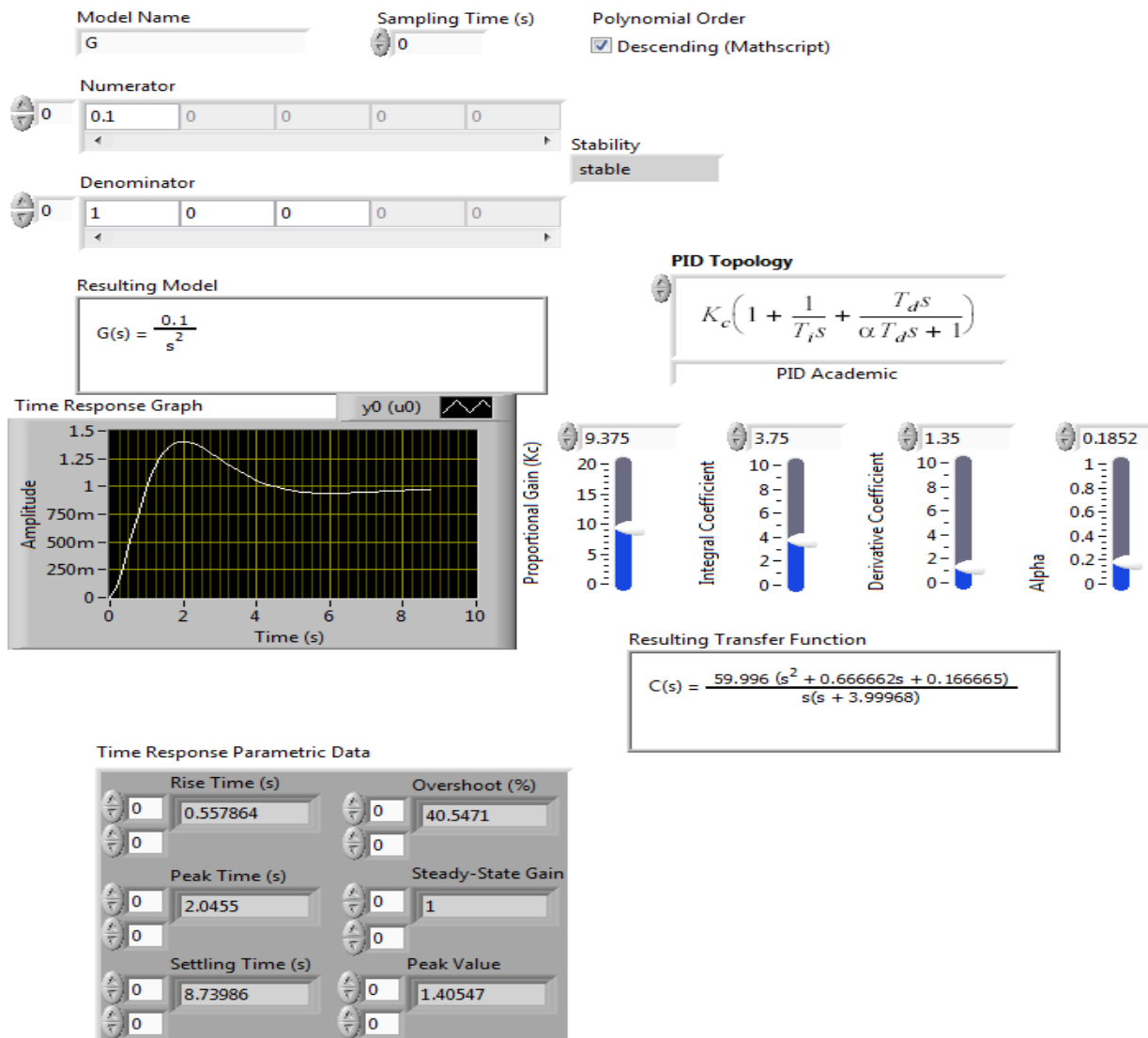


Fig. 2. Step response, time response parametric data, resulting transfer function(controller) and stability analysis for system with controller with tuning parameter=1.

Case 2. Let tuning parameter $\lambda_c = 2$,

So,

$$T_f = .5$$

$$T_i = 7.5$$

$$T_d = 2.7$$

$$k_c = 2.34375$$

The step response and stability can be shown as given in Fig. 3.

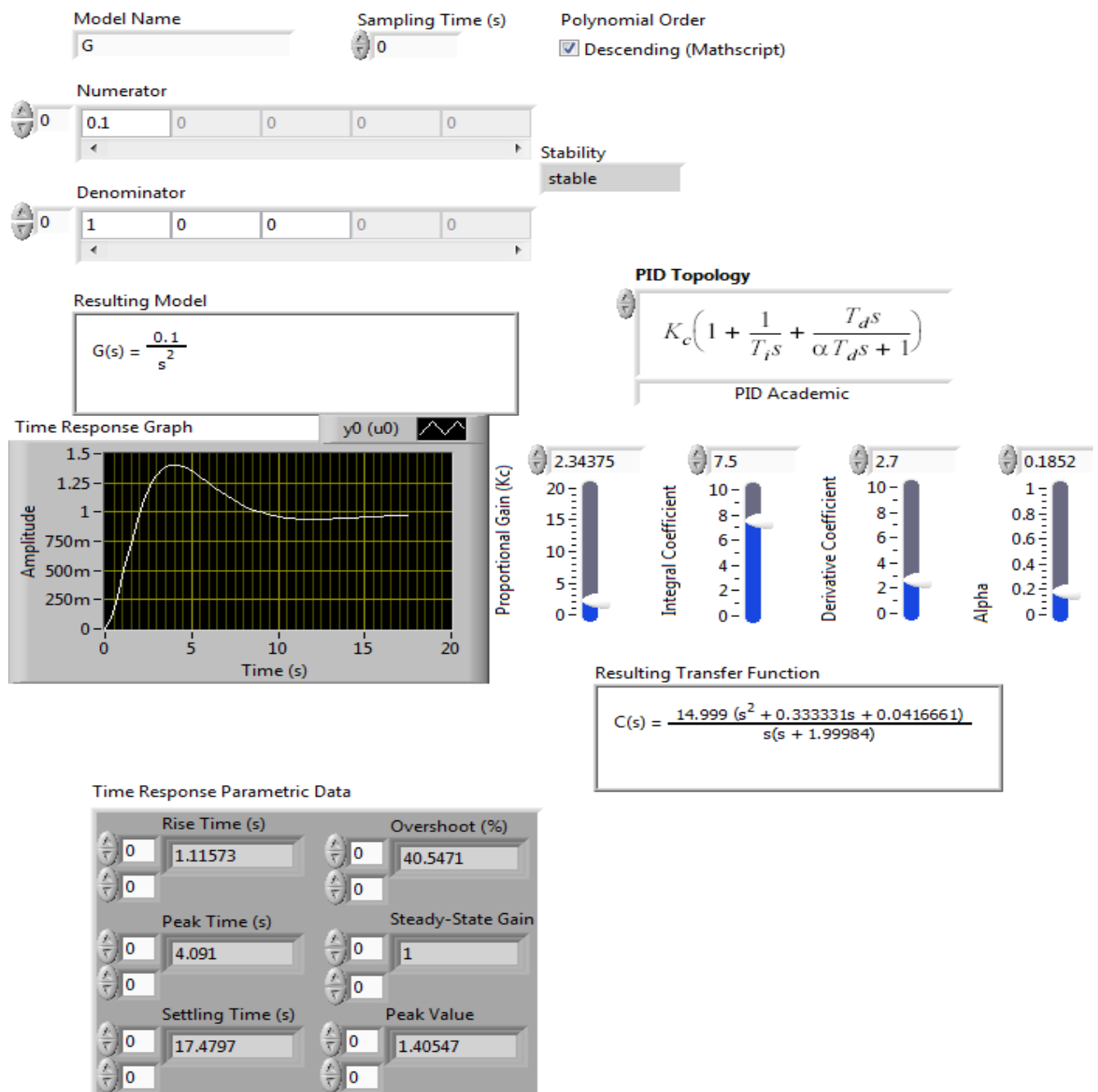


Fig. 3. Step response, time response parametric data, resulting transfer function(controller) and stability analysis for system with controller with tuning parameter =2

The block diagram for above is shown in Fig. 4.

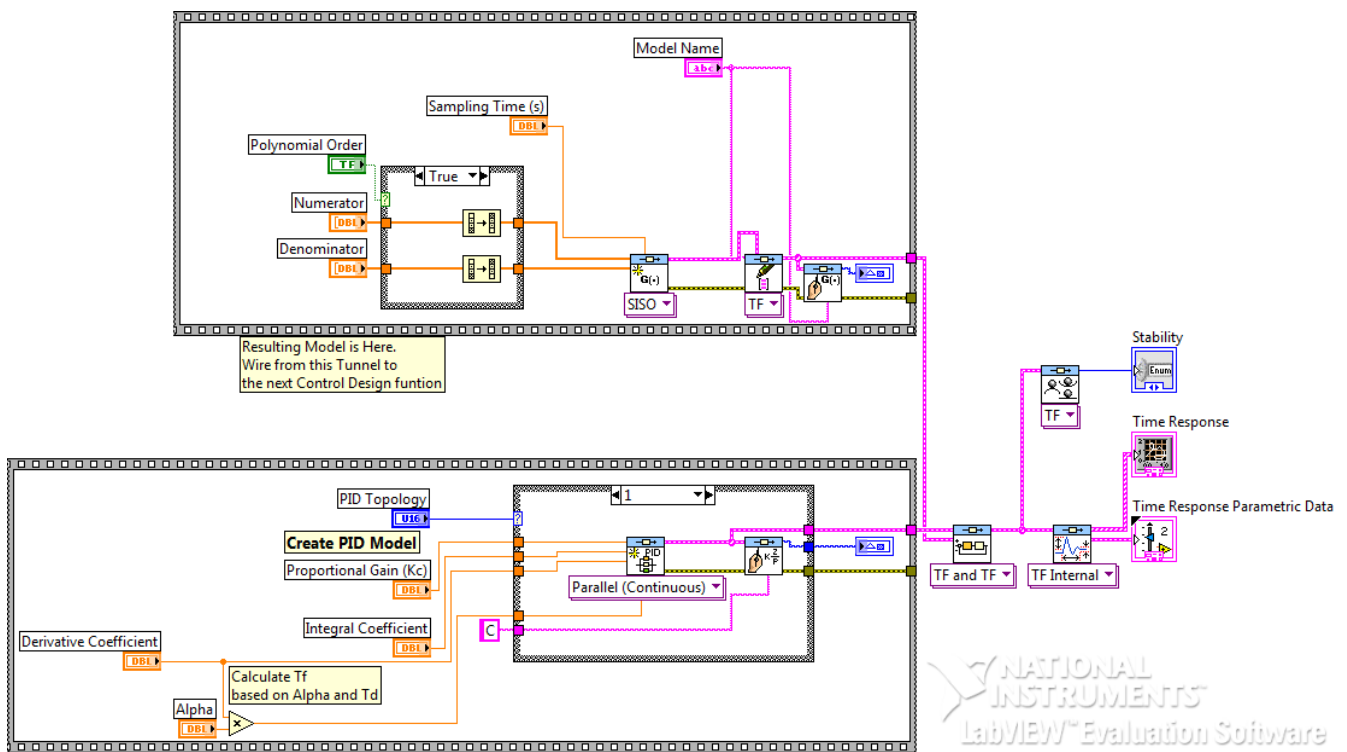


Fig. 4. Block diagram for Step response, time response parametric data, resulting transfer function (controller) and stability analysis for system with controller with different tuning parameters

So the inference is that by varying the tuning parameter, the system with controller can be maintained under stability conditions provided, there is a variation in rise time, peak time and settling time. If tuning parameter is increased these three parameters increases and vice versa. This can be referred to as an adaptive tuning method that is it is a PID controller tuning method by the variation of single tuning parameter.

4. Conclusions

In this paper the system considered is inverted pendulum on a cart. Without considering friction, system modeling is performed. From that it is clear that the system under consideration is a double integrating system which is highly unstable. For designing an adaptive PID controller by variation of only one tuning parameter for the system, Maximum Modulus Theorem is taken into account. From the theorem tuning parameter λ is found. By variation of tuning parameter, different PID values are obtained. So depending upon the requirement in time response parameters such as rise time, peak time and settling time, tuning parameter can be adjusted such that required specifications are met with.

References

- [1]. Doyle J. C and Francis B. A, Feedback control theory, *Macmillan Publishing Company*, 1992.
- [2]. Su Whan Sung and In-Beum Lee, Limitations and countermeasures of PID controllers, *Ind Eng Res.*, 35, 8, 1996, pp. 2596–2610.
- [3]. Sigurd Skogestad, Ian Postlethwaite, Multivariable Feedback control: Analysis and Design, *Wiley*, NY, 1996.

- [4]. Tyreus B. D. and Luyben W. L, Tuning PI controllers for integrator/dead time processes, *Ind. Eng. Chem. Res.* 31, 11, 1992, pp. 2625–2628.
- [5]. Yongho, Lee and Jeonseok Lee, PID controllers tuning for integrating and unstable processes with time delay, *Chemical Engineering Science*, Vol. 55, Issue 17, September 2000, pp. 3481–3493.
- [6]. Weidong Zhang, Xiaoming Xua, Youxians Sunb, Quantitative performance design for integrating process with time delay, *Automatica*, Vol. 35, Issue 4, April 1999, pp. 719–723.
- [7]. Tao Liu, Danying Gu, Weidong Zhang, A H-infinity design method of PID controller for second order process, in *Proceedings of the 42nd IEEE Conference on Decision and Control*, Vol.6, 9-12 Dec. 2003, pp. 6044 – 6049.
- [8]. Katsuhiko Ogatta, Modern Control Engineering, *Prentice Hall of India*, 2010.
- [9]. K. R. Varmah, Control Systems, *Tata McGrawHill Education*, 2010.

2012 Copyright ©, International Frequency Sensor Association (IFSA). All rights reserved.
(<http://www.sensorsportal.com>)

International Frequency Sensor Association



International Frequency Sensor Association (IFSA) is a professional association, created with the aim to encourage the researches and developments in the area of quasi-digital and digital smart sensors and transducers.

IFSA Membership is open to all organizations and individuals worldwide who have a vested interest in promoting or exploiting smart sensors and transducers and are able to contribute expertise in areas relevant to sensors technology.

More than 600 members from 63 countries world-wide including ABB, Analog Devices, Honeywell, Bell Technologies, John Deere, Endevco, IMEC, Keller, Mazda, Melexis, Memsis, Motorola, PCB Piezotronics, Philips Research, Robert-Bosch GmbH, Sandia Labs, Yokogawa, NASA, US Navy, National Institute of Standard & Technology (NIST), National Research Council, etc.



For more information about IFSA membership, visit
<http://www.sensorsportal.com>

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 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 Please download also our media kit: http://www.sensorsportal.com/DOWNLOADS/Media_Kit_2012.pdf



Handbook of Laboratory Measurements and Instrumentation

Maria Teresa Restivo
Fernando Gomes de Almeida
Maria de Fátima Chouzal
Joaquim Gabriel Mendes
António Mendes Lopes

The Handbook of Laboratory Measurements and Instrumentation presents experimental and laboratory activities with an approach as close as possible to reality, even offering remote access to experiments, providing to the reader an excellent tool for learning laboratory techniques and methodologies. Book includes dozens videos, animations and simulations following each of chapters. It makes the title very valued and different from existing books on measurements and instrumentation.



International Frequency Sensor Association Publishing

Order online:

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

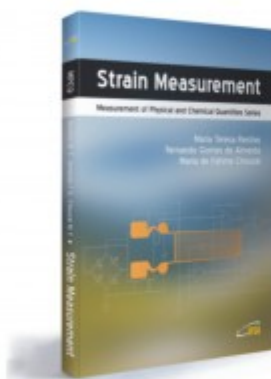


International Frequency Sensor Association (IFSA) Publishing

Maria Teresa Restivo, Fernando Gomes de Almeida, Maria de Fátima Chouzal

Strain Measurement

Measurement of Physical and Chemical Quantities Series



Formats: printable pdf (Acrobat)
and print (hardcover), 106 pages

ISBN: 978-84-616-0067-0,
e-ISBN: 978-84-615-9897-7

'Strain Measurement' deals with measurement of stresses and strains in mechanical and structural components. This topic is related to such diverse disciplines as physical and mechanical sciences, engineering (mechanical, aeronautical, civil, automotive, nuclear, etc.), materials, electronics, medicine and biology, and uses experimental methodologies to test and evaluate the behaviour and performance of all kinds of materials, structures and mechanical systems.

The material covered includes:

- Introduction to the elementary concepts of stress and strain state of a body;
- Experimental extensometry measurement techniques;
- Basic instrumentation theory and techniques associated with the use of strain gauges;
- Optical fibre based extensometry;
- Uncertainty estimation on the measurement of mechanical stress;
- Supplemented multimedia components such as animations, simulations and video clips.

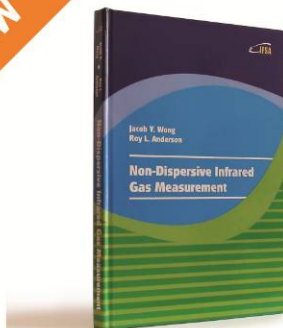
The different subjects exposed in this book are presented in a very simple and easy sequence, which makes it most adequate for engineering students, technicians and professionals, as well as for other users interested in mechanical measurements and related instrumentation.

http://sensorsportal.com/HTML/BOOKSTORE/Strain_Measurement.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



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

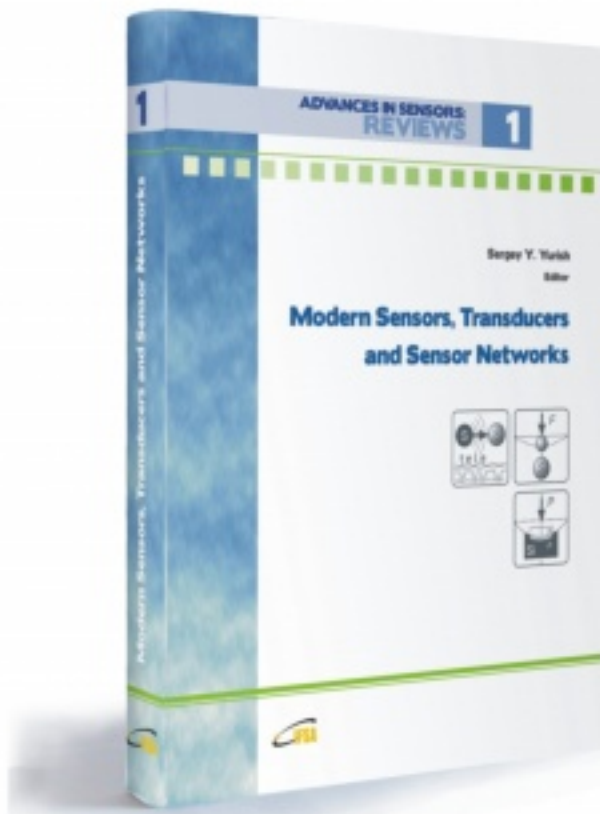
Published Format: printable pdf (Acrobat).

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. 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

**ADVANCES IN SENSORS:
REVIEWS****1****Sergey Y. Yurish**
Editor

Modern Sensors, Transducers and Sensor Networks



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

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

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

Order online:

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



www.sensorsportal.com