Silesian University of Technology
Faculty of Automatic Control, Electronics
and Computer Science

Annual Review 2015

Institute of Electronics

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Institute of Electronics, March 2016

FOREWORD

The Institute of Electronics is a part of the Faculty of Automatic Control, Electronics and Computer Science, one of the 13 faculties of the Silesian University of Technology, founded in 1945. The University is located in Gliwice and has almost 25,000 students at present. The Faculty of Automatic Control was founded in 1964, and after a few reorganisations it changed its name to the Faculty of Automatic Control, Electronics and Computer Science. The total number of students is about 3,000 now. Since its creation in 1974 the Institute of Electronics has undergone a number of reorganisations. It has over 70 members of academic staff and consists of six divisions:

- ***Division of Electronics Fundamentals and Radio Engineering***
- ***Division of Digital and Microprocessor Systems***
- ***Division of Circuit and Signal Theory***
- ***Division of Telecommunication***
- ***Division of Biomedical Electronics***
- ***Division of Microelectronics and Nanotechnology***

The Institute specialises in such advanced fields of engineering as analogue and digital electronic systems, including biomedical systems, production of telecommunication and electronic systems etc. Research in these areas ranges from component to system level, encompassing practical and theoretical investigations with the application of both hardware and software techniques. Research groups are supported by a wide range of test and instrumentation equipment together with computer facilities, which can run with programming languages of all levels and offer various application software. Many of the Institute's research programmes are carried out in close co-operation with industry in order to satisfy the needs of the region, which is the main industrial centre of Poland.

The Institute offers 3.5-year courses leading to the degree of BSc in the general field of Electronics and Telecommunication and 1.5-year MSc courses in the following specialisations:

- Electronic Apparatus
- Biomedical Electronics
- Microelectronics
- Radio Engineering
- Telecommunication

Both degrees are obtained on the basis of a project and a report, presented during a final examination. In addition, the Institute participates in a joint macro-course in Automatic Control, Electronics and Computer Science, run by the Faculty, in which all teaching is in the English language. In the academic year 2013/2014 a completely new course in Information and Communication Technology was started together with the Institute of Informatics. The courses normally consist of lectures, laboratories, seminars and projects, and are followed by examinations. The curricula of the courses run by the Institute are designed for people who want to achieve both theoretical knowledge and

practical skills in electronics. Other didactic activities include postgraduate and PhD studies.

The following pages provide detailed information regarding the research carried out as well as the subjects taught in each division.

CONTENTS

DIRECTORS OF THE INSTITUTE

Director of the Institute:
Prof. Edward HRYNKIEWICZ

Vice Director of the Institute for Research:
Prof. Zdzisław FILUS

Vice Director of the Institute for Teaching:
Asst. Prof. Jacek KONOPACKI

DIVISION OF ELECTRONICS FUNDAMENTALS AND RADIO ENGINEERING

Head of Division: Prof. Zdzisław Filus, PhD, DSc

Research staff

Prof. Zdzisław FILUS, PhD, DSc

Prof. Andrzej KARWOWSKI, PhD, DSc
Andrzej BŁONAROWICZ, PhD
Jacek CHĘCIŃSKI, PhD
Jerzy FIOŁKA, PhD
Zenon KIDOŃ, PhD
Adam KRISTOF, PhD
Sławomir LASOTA, PhD
Mirosław MAGNUSKI, PhD
Andrzej MALCHER, PhD
Artur NOGA, PhD
Wojciech OLIWA, PhD
Maciej SURMA, PhD
Tomasz TOPA, PhD
Grzegorz WIECZOREK, PhD
Dariusz WÓJCIK, PhD

PhD Students

Krzysztof BERNACKI, MSc

Research fields

- Electronic circuits synthesis
- Symbolic methods of electronic circuits analysis
- Electronic circuits for automotive applications
- Power electronic circuits
- Microprocessor-based measurement systems
- Computational electromagnetics
- Numerical modelling of radiating and scattering wire objects
- Linear antenna theory
- Electromagnetic compatibility
- Optoelectronics, Fiberoptics

Courses

- Semiconductor Devices
- Analogue Electronic Circuits
- Analogue Circuits Design
- Fundamentals of Measurements
- Electronic Measurement Techniques
- Switching Circuits
- Special Semiconductor Devices and Circuits
- Materials Technology and Electronic Equipment Design
- Field and Wave Electromagnetics
- Introduction to Radiocommunication
- Radio Engineering Systems
- Fields, Waves and Antennas
- Wireless Computer Networks
- Design of Radio Electronic Devices
- High-Frequency Engineering Fundamentals
- Electromagnetic Compatibility
- Optoelectronics
- Optical Fiber Techniques

DIVISION OF DIGITAL AND MICROPROCESSOR SYSTEMS

Head of Division: Prof. Dariusz Kania, PhD, DSc

Research staff

Prof. Dariusz KANIA, PhD, DSc

Prof. Edward HRYNKIEWICZ, PhD, DSc
Mirosław CHMIEL, PhD
Robert CZERWIŃSKI, PhD
Tomasz GARBOLINO, PhD
Józef KULISZ, PhD
Adam MILIK, PhD
Adam PAWLAK, PhD
Krzysztof PUCHER, PhD
Tomasz RUDNICKI, PhD
Wojciech SAKOWSKI, PhD
Dariusz STACHAŃCZYK, PhD
Krzysztof TABOREK, PhD
Bernard WYRWOŁ, PhD
Dariusz POLOK, MSc

PhD Students

Jarosław WROTNIAK, MSc
Piotr CHODOROWSKI, MSc

Research fields

- Testing and testability of digital systems
  - Test and diagnostics of connections
  - Built-in self-test
  - Generation of test patterns and analysis of test responses
  - Specific linear registers
  - Design for testability
  - Digital systems compliant with IEEE 1149 and IEEE 1500 standards
  - On-line testing
- Design of systems with programmable devices and controllers
  - Design of support software
  - Logic synthesis
  - Technology mapping in CPLDs, FPGAs and pSoCs
  - Fast operating CPU structures of programmable controllers and methods of PLC programming
  - Distributed structures of PLCs
  - PLC applications

- Embedded control system design
- Frequency multipliers based on digital techniques
- Multiprocessor systems
  - Pipelining and parallel processing
  - Systems with global memory and arbitration
  - Statistical analysis of performance for pipelining processing
- ASIC design
  - High level design methodologies
  - System modelling and simulation (using VHDL and Verilog)
  - IP-core design
  - Distributed design methodologies based on the Internet
- Cyber-physical systems
- Field oriented control (FOC) dedicated for a permanent magnet synchronous motor (PMSM)

Courses

- Digital Systems Fundamentals
- Design of Digital Devices
- Microprocessors Fundamentals
- Microprocessor Systems
- Reliability and Testing of Electronic Devices
- Computer Aided Design of Integrated Circuits
- Programmable Logic Devices
- Programmable Controllers
- Hardware Description Languages

DIVISION OF CIRCUIT AND SIGNAL THEORY

Head of Division: Prof. Jerzy Rutkowski, PhD, DSc

Research staff

Prof. Jerzy RUTKOWSKI, PhD, DSc

Damian GRZECHCA, PhD, DSc
Jacek KONOPACKI, PhD, DSc
Andrzej PUŁKA, PhD, DSc
Łukasz CHRUSZCZYK, PhD
Tomasz GOLONEK, PhD
Andrzej KUKIEŁKA, PhD
Jan MACHNIEWSKI, PhD
Katarzyna MOŚCIŃSKA, PhD

PhD Student
Sebastian TEMICH, MSc

Research fields

- Computer-aided electronic circuits analysis and design
  - Test and diagnosis for analogue and mixed-signal electronic circuits
  - Application of sensitivity methods to the analysis and synthesis of electronic circuits
  - Modelling and simulation of digital and mixed analog-digital circuits in VHDL language
  - System level design in SystemC
  - Application of artificial intelligence methods and genetic algorithms to circuit theory and electronics
  - Common-sense reasoning modelling and application of AI techniques to circuits models generation and verification
- Digital signal processing focused on digital filters design and application
- Signal processing and basic research into neural networks (analysis, synthesis and optimisation) and their application to engineering practice
  - Application of neural networks to image processing and recognition, including texture images
  - Application of wavelet techniques to signal processing

- Technology Enhanced Learning (IC-TEL) Web based Education (WBE)
- Indoor location and navigation methods

Courses

- Circuit Theory
- Systems and Signals
- Fundamentals of Electrical Engineering
- Information Theory and Coding
- Computer-Aided Design of Electronic Circuits
- Digital Signal Processing
- Neural Networks
- LabView – Graphical Programming Language
- Computer-Based Measurements with NI LabView

DIVISION OF TELECOMMUNICATION

Head of Division: Asst. Prof. Jacek Izydorczyk, PhD, DSc

Research staff

Asst. Prof. Jacek IZYDORCZYK, PhD, DSc
Leszek DZICZKOWSKI, PhD, DSc
Piotr ZAWADZKI, PhD, DSc
Adam DUSTOR, PhD
Maria DZICZKOWSKA, PhD
Grzegorz DZIWOKI, PhD
Piotr KŁOSOWSKI, PhD
Marcin KUCHARCZYK, PhD
Wojciech SUŁEK, PhD
Jerzy WOJTUSZEK, PhD

Research fields

- Digital commutation in modern telecommunication systems
  - Construction of telephone exchanges
  - Supervisory software for telephone exchanges
  - Special services (e.g. teleconferences)
  - Implementation of digital networks with integrated services (ISDN, B-ISDN, ATM)
- Application of digital signal processing to telecommunication
  - Compression of speech signal with the application of DSPs
  - Speech synthesis
  - Speech and speaker recognition
  - Application of artificial neural networks to signal processing
  - Design, testing and implementation of error correcting and modulating codes
  - Design of modern local area networks
  - Implementation and testing of new services in the Internet
  - xDSL technology
  - Efficient hardware implementation of decoder of LDPC code.
- Modems

Courses

- Fundamentals of Analogue and Digital Communication
- Fundamentals of Commutation
- Switching Nodes and Exchanges
- Principles of Transmission
- Communication Systems
- Signal Theory
- Information Theory and Coding
- Digital Signal Processing
- Computer-Aided Analysis of Electronic Circuits
- Digital Signal Processors (DSP)
- Neural Networks
- Computer Networks
- Internet
- Modems
- Introduction to Cryptography

DIVISION OF BIOMEDICAL ELECTRONICS

Head of Division: Prof. Jacek Łęski, PhD, DSc

Research staff

Prof. Jacek ŁĘSKI, PhD, DSc

Marian KOTAS, PhD, DSc
Tomasz PANDER, PhD, DSc
Ewa STRASZECKA, PhD, DSc
Robert CZABAŃSKI, PhD
Norbert HENZEL, PhD
Jerzy IHNATOWICZ, PhD
Michał JEŻEWSKI, PhD
Michał KOZIELSKI, PhD
Stanisław PIETRASZEK, PhD
Tomasz PRZYBYŁA, PhD

PhD Students

Tomasz MOROŃ, MSc
Sebastian PORĘBSKI, MSc

Research fields

- Biocybernetics and biomedical engineering - processing of information in medicine
  - Processing of biomedical signals
  - Image processing and analysis
  - Fuzzy sets and systems, neuro-fuzzy systems
  - Pattern recognition
  - Cybernetics
  - Computer assisted medical diagnosis
  - Hospital information systems
  - Picture archiving and communications systems
  - Medical information systems integration
  - Expert systems in medicine
  - Time-frequency analysis of biomedical signals
  - Multirate signal processing
  - Evolutionary computations
  - Artificial neural networks
  - Data mining
  - Artificial intelligence
- Design, construction and testing of electronic medical equipment
  - Design and construction of amplifiers for biological signals and data acquisition systems co-operating with computers

- Testing of electromedical equipment
- Design of electronic devices for data acquisition

Courses

- Electromedical Metrology
- X-ray and Nuclear Imaging
- Medical Information Systems
- Cybernetics
- Artificial Intelligence
- Electromedical Equipment
- Pattern Recognition
- Principles of Knowledge Engineering
- Diagnostic Imaging Systems
- Biocybernetics
- Computers in Medicine
- Diagnostic Cardiological Systems
- Computer Aided Medical Diagnosis
- Probability Theory and Mathematical Statistics
- Optimization Methods
- Bionics
- Principles of Digital Signal Processing
- Numerical Methods
- Biomedical Information Processing
- Digital Signal Processing
- Artificial Intelligence in Engineering Applications

DIVISION OF MICROELECTRONICS AND NANOTECHNOLOGY

Head of Division: Prof. Jacek Szuber, PhD, DSc

Research staff

Prof. Jacek SZUBER, PhD, DSc

Prof. Zbigniew RYMARSKI, PhD, DSc
Monika KWOKA, PhD, DSc
Krzysztof WACZYŃSKI, PhD, DSc
Wojciech FILIPOWSKI, PhD
Weronika IZYDORCZYK, PhD
Piotr KOŚCIELNIAK, PhD
Piotr KOWALIK, PhD
Jerzy ULJANOW, PhD
Edyta WRÓBEL, PhD

Research fields

- Design of electronic devices for data acquisition
- Technology of doped semiconductor glasses based on organosilicon compounds
- Special hybrid circuits made in thick (thin) film technology
- Solar cells and photovoltaic systems
- Passivation of semiconductor surfaces for application in microelectronics
- Nanotechnology of transparent conductive oxides and organic semiconductors for application in photovoltaics and gas sensors
- Thin film resistive layers

Courses

- Design of Thick/Thin-Film Circuits
- Fundamentals of Physics
- Hybrid Circuit Technology
- Electronic Devices, Semiconductor Structures and Circuits
- Materials Science and Principles of Construction of Electronic Equipment
- Microelectronics
- Nanotechnology in Microelectronics
- Solid State Electronics
- Sensors and Actuators
- Thick-Film Technology
- Thin-Film Technology

SECRETARIAL AND TECHNICAL STAFF

Secretarial staff

Beata BIELAWNY, MBA
Agata CUDAK-TUTAJEWICZ, MSc (since 1 December 2015)
Edyta KAWA, MSc (till 31March 2015)
Maria LANGIER
Tatiana NIEDZIELA, BBA

Technical staff

Andrzej CZYŻ, MSc
Dariusz KOLKA, MSc (since 16 October 2015)
Łucja LEWANDOWSKA
Szymon PARA, MSc
Tomasz SZYMAŃSKI, BSc
Natalia WACZYŃSKA–NIEMIEC, MSc
Jarosław WROTNIAK, MSc
Piotr ZAJĄC
Czesław ZIOBER

STATUTORY ACTIVITIES OF THE INSTITUTE OF ELECTRONICS

DSc DEGREES CONFERRED ON STAFF MEMBERS OF THE INSTITUTE OF ELECTRONICS

1. **Krzysztof Waczyński** – DSc examination on the basis of the monograph entitled "Tin dioxide thin films for microelectronics application" took place at the Faculty of Automatic Control, Electronics and Computer Science, Silesian University of Technology, on 12 May 2015.

2. **Tomasz Pander** – DSc degree conferred on the basis of a series of publications entitled "The nonlinear, robust filtering in biomedical signal processing in the presence of an impulsive noise", Faculty of Automatic Control, Electronics and Computer Science, Silesian University of Technology, 26 May 2015.

3. **Monika Kwoka** – DSc degree conferred on the basis of a series of publications entitled "Technology and characterization of the selected low dimensional tin dioxide SnO_2 nanostructures in aspect for sensor application", Faculty of Automatic Control, Electronics and Computer Science, Silesian University of Technology, 29 September 2015.

PhD DEGREES CONFERRED ON STAFF MEMBERS AND PhD STUDENTS OF THE INSTITUTE OF ELECTRONICS

1. **Zbigniew Budzianowski**, The use of advanced methods of spectral and statistical assessment of the rehabilitation of patients after ischemic stroke, PhD advisor: Prof. Ewaryst Tkacz, 7 July 2015.

2. **Michał Sitarz**, Comparative analysis of the surface properties of tin dioxide SnO_2 one-dimensional and two-dimensional nanostructures, PhD advisors: Prof. Jacek Szuber and Monika Kwoka, 13 July 2015

RESEARCH GRANTS

Research activities of the Institute of Electronics are mainly financed by the Ministry of Science and Higher Education within the frames of a general research programme:

- ***Development of new research areas in electronics, telecommunication and signal processing***

Apart from this, each division of the Institute carries out its own research in the following general areas, which are further subdivided into individual research projects:

Division of Electronics Fundamentals and Radio Engineering:

- *Electronic components, circuits and systems - development of measurement methods, analysis and synthesis*

Division of Digital and Microprocessor Systems:

- *Multiprocessor systems, application specific integrated circuits, programmable logic devices and systems - analysis, design and testing*

Division of Circuit and Signal Theory:

- *Computer-aided methods of analysis, synthesis and testing of electronic systems and their selected applications*

Division of Telecommunication:

- *Development of methods and applications of digital channel commutation and transmission of digital signals, theoretical and experimental methods of examination of bodies radiating and dissipating electromagnetic waves*

Division of Biomedical Electronics:

- *Acquisition and processing of biomedical information*

Division of Microelectronics and Nanotechnology:

- *Advanced technology in microelectronics and nanoelectronics*

In total, forty two individual research projects were completed in 2015.

GRANTS AWARDED BY THE COMMISSION OF EUROPEAN COMMUNITIES OR OTHER INTERNATIONAL SOURCES

1. Dependable Cyber-Physical Systems. Project DAAD (Deutscher Akademischer Austausch Dienst) No. 56268155
Coordination: A. Pawlak, PhD
Collaboration with Brandenburg University of Technology in Cottbus (Prof. H.T. Vierhaus) is realised in a frame of the DCPS (Dependable Cyber Physical Systems) project. DCPS is a network project of the German DAAD-Program „Strategic Partnerships and Thematic Networks“ (2013-2016). The project supports organisation of doctoral workshops and exchange of PhD students and professors doing research in the area of dependable cyber physical systems. Information on DCPS network activities is available on the following web pages:
http://www.iele.polsl.pl/~pawlak/DCPS/index.htm
http://www.iele.polsl.pl/~pawlak/DCPS/index-DCPS.htm
These web pages are accessible from the Institute's home page (Bookmark: *Projects*).

2. Innovative speaker recognition methodology for communications network safety. A structural project financed by the European Fund for Regional Development within the Operational Programme of Innovative Economy in a consortium formed by Silesian Technical University and Samsung: POIG.01.03.01-24-107/12, Period: 2013 – 2015
Coordination: J. Izydorczyk, PhD, DSc
The objectives of the project are: 1) Determination how certain parameters affect the process of speaker identifying. 2) Comparative studies of solutions produced in Task 1. 3) The effect of speaker model for speaker identification process. 4) Different approaches to the optimization of the system created Task 2. 5) Tests of the identification system in Matlab environment. 6) Verification and optimization of the computer code provided by the research unit within the task 3.

3. Increasing the professional competence of students studying Electronics and Telecommunication at Silesian University of Technology. A project financed by the European Social Fund and the National Centre for Research and Development within the Operational Programme - Human Capital - Measure 4.1 Strengthening and Development of Didactic Potential of Universities and Increasing the Number of Graduates from Faculties of Key

Importance for Knowledge-Based Economy. Grant Number: POKL.04.01.01-00-073/14 Period: 1.10.2014–30.09.2015
Coordination: D. Grzechca, PhD, DSc
The main objective of the project is to prepare graduates for entering the labour market by offering certified courses and national/international internships.

4. New Trends in Electronics, A grant financed by Motorola Solutions. Period: 1.01.2015–31.12.2015
Coordination: D. Grzechca, PhD, DSc
The goal of this grant is to start two different courses to teach students about modern methods used for design of electronic devices and new trends in electronic and telecommunications systems: a) System-on-a-Chip: hardware-software design, b) Radiocommunication Systems/Introduction to Radiocommunication Systems.

RESEARCH GRANTS AWARDED BY NATIONAL SOURCES

1. Advising support in verification methodology of integrated circuits – Project No. U-613/RAu-3/2015, financed by Evatronix S.A., a private company from Bielsko-Biała
Coordination: Prof. E. Hrynkiewicz
The aim of this project is to provide consulting services in the field of modern methodology verification of integrated circuits. For this purpose the following methodologies are considered: Universal Verification Methodology (UVM), virtual prototyping and device emulation. All of these approaches are carried out on the basis of recognition of the present knowledge state and the comparative studies of technological solutions presented in the literature.

2. Development of techniques to improve the reliability of measurements of bioelectric signals in real electromagnetic environment –National Centre for Research and Development, Agreement No. PBS3/B3/34/2015, Period: 01-05-2015 - 30-04-2017
Coordination: D. Wójcik, PhD
The main goal of the project is to develop new methods of increasing the reliability of the measurement of low-level biomedical signals recorded in real electromagnetic environment by medical devices, such as electroencephalogram or high-resolution electrocardiogram, having a high sensitivity to electromagnetic disturbances. The result of the work will be

development of the hardware and software methods for detection of influence of disturbances produced by wireless communication systems. In the first stage a database of real disturbances for typical electromagnetic environment will be performed. Subsequently, simulation and measurement methods will be utilized to explore coupling phenomena of EM disturbances to medical devices. This research will lead to the design of hardware and software detection methods allowing to identify those parts of the registered signal that do not provide any diagnostic value due to the presence of the disturbances.

3. Testing and diagnostics of interconnections between digital cores of Systems-on-Chip. The project (DSc grant) is financed by the Rector of Silesian University of Technology. Grant Number: RGH- 11/RAU3/2014.
Period: 1.10.2014-31.12.2015.
Coordination: T. Garbolino, PhD
The main objective of the grant is to prepare the whole documentation that is required to apply for the DSc degree. One of the major outcomes of the grant is a monograph devoted to various methods of detection, localization and identification of static and dynamic faults in lines connecting digital cores in Systems-on-Chip. It is mainly focused on applications of linear feedback registers – including specific linear ring registers – in interconnect built-in self-test structures.

INTERNATIONAL CO-OPERATION

1. University of Brescia, Italy (Prof. J. Szuber, Dr M. Kwoka)
2. University of L'Aquila, Italy (Prof. J. Szuber, Dr M. Kwoka)
3. Technical University of Ostrava, Department of Measurements and Control, Czech Republic (Prof. E. Hrynkiewicz)
4. Tomas Bata University, Department of Computer and Communication Systems, Zlín, Czech Republic (Prof. E. Hrynkiewicz)
5. Brandenburg University of Technology, Cottbus, Germany (Dr A. Pawlak, Prof. E. Hrynkiewicz)

SCIENTIFIC CONFERENCES ORGANISED AND CO-ORGANISED BY THE INSTITUTE OF ELECTRONICS

Programmable Devices and embedded Systems (PDeS 2015), The 13th IFAC/IEEE International Conference, Cracow, Poland, 13-14 May 2015 (Prof. E. Hrynkiewicz, Dr A. Milik)

The 9th International Workshop on Semiconductor Gas Sensors - SGS 2015, Zakopane, 13-16 December 2015 (Prof. J. Szuber, Dr M. Kwoka)

STAFF MEMBERS PARTICIPATING IN SCIENTIFIC AND ORGANISING COMMITTEES OF CONFERENCES AND SYMPOSIA

International

1. **Dr R. Czerwiński**, Organizing Committee, 13th IFAC/IEEE International Conference on Programmable Devices and Embedded Systems (PDeS'15), 13-14 May 2015, Cracow
2. **Dr T. Garbolino**, Steering Committee and Program Committee, 18th IEEE Symposium on Design and Diagnostics of Electronic Circuits and Systems, DDECS 2015, 22-24 April 2015, Belgrade, Serbia
3. **Dr T. Garbolino**, Program Committee, 18th Euromicro Conference on Digital System Design (DSD), special session Dependability, Testing and Fault Tolerance in Digital Systems, 26-28 August 2015, Funchal, Madeira, Portugal
4. **Prof. E. Hrynkiewicz**, Organizing Committee Chair, 13th IFAC/IEEE International Conference on Programmable Devices and Embedded Systems (PDeS'15), 13-14 May 2015, Cracow
5. **Prof. E. Hrynkiewicz**, Program Committee Vice-chair, 13th IFAC/IEEE International Conference on Programmable Devices and Embedded Systems (PDeS'15), 13-14 May 2015, Cracow
6. **Prof. E. Hrynkiewicz**, Program Committee, The International Scientific Conference: Computer Networks-CN'15, 16-19 June 2015, Brunów Palace, Poland
7. **Prof. E. Hrynkiewicz**, Steering Committee and Program Committee, 18th IEEE Symposium on Design and Diagnostics of Electronic Circuits and Systems, DDECS 2015, 22-24 April 2015, Belgrade, Serbia

8. **Prof. E. Hrynkiewicz**, Program Committee, 11th IEEE International Conference: Beyond Databases, Architectures and Structures BDAS'2015, 26-29 May 2015, Ustroń, Poland
9. **Prof. D. Kania**, organizer of the session, 11th International Conference of Computational Methods in Science and Engineering, ICCMSE 2015, 20-23March 2015, Athens, Greece
10. **Prof. D. Kania**, Program Committee, 19th International Conference Electronics 2015, 15-17 June 2015, Palanga, Lithuania
11. **Prof. D. Kania**, Programme Committee, 13th IFAC/IEEE International Conference on Programmable Devices and Embedded Systems (PDeS'15), 13-14 May 2015, Cracow
12. **Prof. D. Kania**, Scientific Committee, 3rd International Conference "Graph Modelling In Engineering", 22 - 24 June 2015, Bielsko-Biała, Poland
13. **Prof. A. Karwowski**, Programme Committee, 23rd International Conference on Electromagnetic Disturbances (EMD 2015), 09-11 September 2015, Białystok, Poland
14. **Dr P. Kłosowski**, Programme Committee, International Multi-Conference on Engineering and Technological Innovation, IMETI 2015, 12-15 July 2015, Orlando, Florida, USA
15. **Dr P. Kłosowski**, Programme Committee, International Symposium on Engineering Education and Educational Technologies, IEEE 2015, 12-15 July, Orlando, Florida, USA
16. **Dr M. Kwoka**, Chairwoman, 9th International Workshop on Semiconductor Gas Sensors (SGS 2015), 13-16 December 2015, Zakopane, Poland
17. **Prof. J. Łęski**, Scientific Committee, International Conference on Man-Machine Interactions, 6-9 October 2015, Kocierz, Poland
18. **Dr A. Milik**, Organizing Committee co-chair, 13th IFAC/IEEE International Conference on Programmable Devices and Embedded Systems (PDeS'15), 13-14 May 2015, Cracow
19. **Dr A. Milik**, Programme Committee, 13th IFAC/IEEE International Conference on Programmable Devices and Embedded Systems (PDeS'15), 13-14 May 2015, Cracow
20. **Dr A. Pawlak**, Programme Committee, 18th Euromicro Conference on Digital System Design (DSD15), 26-28 August 2015, Funchal, Madeira, Portugal

21. **Dr A. Pawlak**, Program Committee, 18th IEEE Symposium on Design and Diagnostics of Electronic Circuits and Systems, DDECS 2015, 22-24 April 2015, Belgrade, Serbia
22. **Dr A. Pawlak**, Programme Committee, 6th IFIP Working Conference on Virtual Enterprises - Risks and Resilience of Collaborative Networks, 5-7 October 2015, Albi, France
23. **Dr A. Pawlak**, Programme Committee, 8th International Conference on Advances in Circuits, Electronics and Micro-electronics (CENICS 2015), 23–28 August 2015, Venice, Italy
24. **Dr A. Pawlak**, Programme Committee, 12th IEEE International Workshop of Electronics, Control, Measurement, Signals and their application to Mechatronics (ECMSM 2015), June, 2015, Liberec, Czech Republic
25. **Dr A. Pawlak**, IFIP/IEEE International Conference on Very Large Scale Integration (VLSI-SoC), 5-7 October 2015, Daejeon Convention Center, Daejeon, Korea
26. **Dr A. Pawlak**, 10th IEEE International Conference on Computer Engineering and Systems (ICCES 2015), 23-24 December 2015, Cairo, Egypt
27. **Dr A. Pułka**, Programme Committee, 13th IFAC/IEEE International Conference on Programmable Devices and Embedded Systems (PDeS'15), 13-14 May 2015, Cracow
28. **Dr A. Pułka**, Session organizer, Modern Techniques of Design and Implementation of Highly Flexible Controllers, (PDeS'15), 13-14 May 2015, Cracow
29. **Prof. J. Rutkowski**, Scientific Committee, 22nd International Conference on Mixed Design of Integrated Circuits & Systems (MIXDES), 25-27 June 2015, Toruń, Poland
30. **Prof. J. Rutkowski**, Program Committee, 2nd International KES Conference on Smart Education and E-Learning (KES-SEEL-15), 17-19 June 2015, Sorrento, Italy
31. **Dr W. Sakowski**, Programme Committee chair from industry, 13th IFAC/IEEE International Conference on Programmable Devices and Embedded Systems (PDeS'15), 13-14 May 2015, Cracow
32. **Dr W. Sułek**, Technical Programme Committee, 38th International Conference on Telecommunications and Signal Processing (TSP) 2015, Prague, Czech Republic

33. **Prof. J. Szuber**, Director of 9th International Workshop on Semiconductor Gas Sensors (SGS 2015), 13-16 December 2015, Zakopane, Poland
34. **Dr K. Waczyński**, Scientific Committee, 39th International Microelectronics and Packaging IMAPS Poland Conference, 20-23 September 2015, Gdańsk, Poland

National

1. **Prof. Z. Filus**, Scientific Committee member of 14th National Electronics Conference, 8-12 June 2015, Darłowo
2. **Prof. E. Hrynkiewicz**, Scientific Committee member of 14th National Electronics Conference, 8-12 June 2015, Darłowo
3. **Prof. E. Hrynkiewicz**, Scientific Committee member of 18th Conference on Reconfigurable Ubiquitous Computing, RUC 2015, 17-18 September 2015, Szczecin
4. **Prof. D. Kania**, Scientific Committee member of 18th Conference on Reconfigurable Ubiquitous Computing, RUC 2015, 17-18 September 2015, Szczecin
5. **Prof. A. Karwowski**, Scientific Committee member of National Conference on Radiocommunications and Broadcasting, 8-10 April 2015, Łódź
6. **Dr A. Milik**, Scientific Committee member of 18th Conference on Reconfigurable Ubiquitous Computing, RUC 2015, 17-18 September 2015, Szczecin
7. **Prof. J. Rutkowski**, Scientific Committee member of 14th National Electronics Conference, 8-12 June 2015, Darłowo
8. **Prof. J. Szuber**, Scientific Committee member of 13th Seminar: Surface and Thin Films Structures (PiSC2015), 16-18 September 2015, Szklarska Poręba
9. **Prof. J. Szuber**, Scientific Committee member of 7th National Conference of Nanotechnology, 25-27 June 2015, Poznań

REVIEWERS

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8. **Prof. E. Hrynkiewicz**, Journal of Applied Logic, Journal of Circuits, Systems and Computers; International Journal of Electronics and Telecommunication, Szybkobieżne Pojazdy Gąsienicowe, Journal of Applied Mathematic, IEEE DDECS Symposium, Elsevier Journal on Microprocessors and Microsystems, International IFAC/IEEE Conference on Programmable Devices and Embedded Systems, International Conference Beyond Databases Architectures and Structures, International Science Conference on Computer Networks, International Conference on Artificial Intelligence and Soft Computing, National Electronics Conference, The 18th Conference on Reconfigurable Ubiquitous Computing RUC'2015
9. **Dr J. Izydorczyk**, Physica B - Condensed Matter; PIER & JEMVA (Progress In Electromagnetics Research, Journal of Electromagnetic Waves and Applications), Micro & Nano Letters from the Institution of Engineering and Technology (IET), IEEE Transactions on Circuit and

Systems I, IEEE Transactions on Magnetics, Journal of Applied Physics from American Institute of Physics (AIP), International Journal of Electronics and Telecommunications, Studia Informatica

10. **Dr M. Jeżewski**, Journal of Medical Imaging and Health Informatics, Journal of Medical Informatics and Technologies
11. **Prof. D. Kania**, Bulletin of the Polish Academy of Sciences – Technical Sciences, International Journal of Electronics and Telecommunication, International Journal of Applied Mathematics and Computer Science, Journal of Circuits, Systems and Computers; Electronics and Electrical Engineering, International Conference Information Technology Interfaces, International Conference Electronics 2015, International Conference of Computational Methods in Science and Engineering, International Conference "Graph Modelling in Engineering", International IFAC Conference on Programmable Devices and Embedded Systems, National Conference on Reconfigurable Ubiquitous Computing, Measurement Automation Monitoring, Przegląd Elektrotechniczny, Elektronika – Konstrukcje, Technologie, Zastosowania
12. **Prof. A. Karwowski**, Journals: IET Proceedings Microwaves, Antennas & Propagation (London), Electronics Letters; IEEE Transactions on Antennas and Propagation; IEEE Transactions on Microwave Theory and Techniques; Progress in Electromagnetics Research, International Journal of Microwave and Wireless Technologies; COMPEL: The International Journal for Computation and Mathematics in Electrical and Electronic Engineering; Conferences: European Microwave Conference, EMC Europe, International Conference on Microwaves, Radar & Wireless Communications (MIKON)
13. **Dr P. Kłosowski**, International Symposium on Engineering Education and Educational Technologies, EEET 2015, Orlando, Florida, USA, International Multi-Conference on Engineering and Technological Innovation, IMETI 2015, Orlando, Florida, USA, IEEE International Conference on Signal Processing, Informatics, Communication and Energy Systems 2015 (IEEE SPICES 2015)
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19. **Dr A. Milik**, 13th IFAC/IEEE International Conference on Programmable Devices and Embedded Systems (PDeS 2015), Kraków, International Conference of Computational Methods in Sciences and Engineering (ICCMSE 2015) Special Session: Logic Synthesis and Control Systems, Advances in Electrical and Electronic Engineering (AEEE), ISA Transactions
20. **Dr T. Pander**, IEEE Transactions on Signal Processing
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26. **Dr T. Topa**, International Journal of Numerical Modelling: Electronic Networks, Devices and Fields; IEEE Antennas and Wireless Propagation Letters

27. **Dr K. Waczyński**, 39th International Microelectronics and Packaging IMAPS-CPMT Poland Conference
28. **Dr D. Wójcik**, Progress in Electromagnetics Research
29. **Dr P. Zawadzki**, Ukrainian Scientific Journal of Information Security, Theoretical and Applied Informatics, International Journal of Quantum Information, Communications in Control Science and Engineering, Quantum Information and Computation, Scientific Report

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51. **Prof. J. Rutkowski**, member of the Electronics and Telecommunication Committee, Polish Academy of Sciences

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PATENTS AND PATENT APPLICATIONS

Wieczorek G. (PhD), Patent No. 220168 of 30 September 2015, ”Method and Device for Distance Measurement”

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Dr M. Kwoka - Scientific Fellowship of the Polish Ministry of Science and Higher Education for the Prominent Young Scientist for the period 2013-2016

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ABSTRACTS OF SELECTED RESEARCH PROJECTS

DIVISION OF ELECTRONICS FUNDAMENTALS AND RADIO ENGINEERING

Prof. Z. Rymarski, K. Bernacki (MSc), *The influence of Z-Source output impedance on dynamic properties of single-phase voltage source inverters for UPS*

Using a Z-Source type impedance network to step up the input DC voltage is a solution that has been used for the last ten years to increase the output voltage of a voltage source inverter (VSI). The basic version of a Z-Source circuit has a disadvantage – a discontinuous input current. The Z-Source-like topologies, e.g., the LCCT qZSI (inductor-capacitor-capacitor-transformer quasi Z-Source) that were presented ensure a continuous input current. The Z-Source circuit, like most of the step-up DC/DC converters, stores energy in the inductances. These inductances always have an influence on the control transfer function of the VSI. The research enabled the estimation of the influence of the output impedance of a Z-Source circuit on the small signal control transfer function of a single-phase H-bridge, 3-level voltage source inverter. The dynamic small signal modelling of the Z-Source was based on averaging the state space, what is a standard approach in the analysis of DC/DC converters. The original algorithm of the Z-Source impedance network design, which keeps it in the continuous current mode, was presented. The analysis of the theoretical model and its final experimental verification for the different current modes and operating points of the inverter with a Z-Source impedance network can help to estimate the necessity of taking into account the influence of Z-Source output impedance during the design of a VSI control loop. The logical chain of the VSI with a Z-Source network design was elaborated and concluded with a small signal analysis. An inverter output LFCF filter design is necessary for the calculation of the inverter control function. The new five-point algorithm for the design of a Z-Source impedance network was published. The calculations of the small signal output impedance of the Z-Source circuit, which are based on averaging the state space were published. The control transfer function of the inverter including the impact of the output impedance of the Z-Source circuit was calculated and verified by means of the experimental model. The Z-Source introduces two additional resonant frequencies into the nominator and the denominator of the transfer function that are much below the resonant frequency of the output inverter filter but very close to each other. Their influence on the control function very strongly depends on the load and the damping serial parasitic resistances in the Z-Source and the DC source output impedance. Even small values of the parasitic resistances in the Z-Source introduce a strong damping because they are multiplied by the square of the voltage amplification ratio. It can be noticed that the influence of the Z-Source is more serious in the discontinuous current mode. The Z-Source influence can be presented as an additional serial block in the control transfer function block diagram. A new method

of measuring the Bode plots of the control transfer function of the voltage source inverter was implemented to discuss the theoretically calculated and measured characteristics.

Prof. A. Karwowski, A. Noga (PhD), T.Topa (PhD), *Implementation of the Method-of-Moments on heterogeneous CPU/GPU platforms*

Frequency-domain (FD) integral equation (IE) formulation combined with the Method-of-Moments (MoM) constitutes one of flagship computational electromagnetics (CEM) tools, which has proven its efficiency in a vast variety of electromagnetic engineering problems. The FD-IE-MoM approach comprises two computationally intensive phases, that is, assembling the system matrix and then solving the resulting matrix equation. The performance of the overall approach can be noticeably increased by extending a traditional CPU-based computation model through adoption of the heterogeneous computing paradigm. The main purpose of the study was to examine the performance and scalability of a hybrid OpenMP/CUDA parallelization technique in the context of electromagnetic simulation of wire-grid models of antennas and scatterers. A single-CPU sequential code based on the discretized EFIE was ported using OpenMP and CUDA to heterogeneous multi-core CPU/ single GPU platform. The assembly of the system matrix has been carried out by a single CUDA kernel. For the solution of the matrix equation, an in-house hybrid CUDA-panel-based out-of-GPU memory LU decomposition algorithm is implemented. On an Intel quad-core i7-3820 host with NVIDIA's GeForce GTX 680 device, the total solution time (for matrices as large as the main system storage) is reduced by 30% compared to a highly optimized four-core MKL-based reference implementation. The overall problem has been considered from the position of a user of a rather typical low-cost PC-style workstation. This perspective is justified by the fact that multi-core CPUs combined with GPUs have recently gained popularity in scientific computing as an inexpensive heterogeneous massively parallel architecture available to the masses.

A. Malcher (PhD), *Current-programmable Universal Biquad Filter Based on Modified Current Differencing Transconductance Amplifier*

This research work deals with a new current programmable active element called Modified Current Differencing Transconductance Amplifier (MCDTA). The proposed circuit can be implemented in CMOS technology. The parameters of the circuit – input resistance and transconductance – can be tuned by control currents. The circuit with several external components – diodes and grounded capacitors – makes it possible to build basic analog circuits: first order and second order tunable active filters, rectifiers, peak detectors and others. One application which is a current mode counterpart of the well known KHN active filter is analyzed in detail. The circuit has different tuning capabilities. One can tune the center frequency or quality factor using programming currents. This feature can be very useful, for example, in reconfigurable antialiasing filters. The simulation results proved the advantages of the circuit. The MCDTA seems

to be an interesting component which can be implemented in a mixed mode programmable signal processing system – for example continuous time Field Programmable Analog Array (FPAA).

DIVISION OF DIGITAL AND MICROPROCESSOR SYSTEMS

Prof. E. Hrynkiewicz, A. Milik (PhD), M. Chmiel (PhD), R Czerwiński (PhD), J. Kulisz (PhD), B. Wyrwoł (PhD), A. Malcher (PhD), *Fast Logic Controllers*

An efficient execution of a control program written according the IEC61131-3 standard is a subject of our multi-domain research program. The main goals of the project are reducing a response time and increase a throughput of the control system. There are two paths to achieve these goals. The standard approach proposes the implementation of highly specialized central processing units and entire controllers that closely adhere to the IEC61131-3 standard. There are proposed multicore central processing units with extended support of time and counting operations. The developed hardware architecture is evaluated with the use of FPGAs and supported with a respective compiler. The compiler uses enhanced data flow graphs for extracting parallel tasks and distributing them among the processing units. The experience gained in program compilation has encouraged for developing a unique hardware–supported event–driven execution concept.
The other approach proposes synthesis of the custom hardware structure of the control program implemented in FPGA. There have been developed different methods of control program synthesis to hardware structure. The graph and set analysis are employed for this purpose. The controller implemented from Ladder or Instruction List implementing only Boolean operations requires two clock cycles to complete the calculation process independently of the program complexity. The developed representation method based on the enhanced data flow graph enables synthesis, scheduling and mapping not only logic but also arithmetic operations. The mapping procedure enables arithmetic resource sharing and use of highly dedicated DSP FPGA cores (e.g. DSP48E). The obtained hardware structures are able to operate as extremely fast feedback controllers.
Logic controllers utilize advanced control algorithms based on Fuzzy logic concepts. An efficient implementation of fuzzy algorithms with the use of software and hardware implementation is an area of interest for the group. An optimization of the Mamdani's inference method has been developed. It resulted in the reduction of both the rules database size and the complexity of the inference system by introducing merge of rules calculation. The introduced optimizations and improvements have allowed to reduce both system resource requirements and a computation time of the crisp output.

Prof. D. Kania, *Technology mapping oriented to programmable logic devices*

Logic synthesis transforms a functional description of a digital circuit into a hardware implementation. Technology mapping is the process of expressing a Boolean network in terms of elements specific for a given programmable architecture (CPLD, FPGA). The research work was oriented on technology mapping algorithms targeted to PAL-based CPLDs and LUT-based FPGAs.
The first method is based on a unique representation of the multi-output Boolean function. The essence of the method concentrates on the process of searching for the common multi-output implicants based on the analysis of graph's nodes representing the output vectors. The suggested algorithms of technology mapping have their foundation in the theorem on choosing a node of the graph outputs. A new method for the optimization of feedback can be found, which leads to the appropriate modification of those nodes constituting the graph of outputs.
Decomposition is an extremely valuable component of synthesis. First of all, it influences directly the number of logical blocks. The unusual application of the classical theory to the decomposition is discussed too. The algorithms developed are derived from the classical model of the functional decomposition that was introduced by Curtis. The individual phases of the decomposition are prepared for the PAL-based CPLD and LUT-based FPGA structures. An innovative type of SMTBDD (Shared Multi Terminal Binary Decision Diagram) is proposed. The proposed form of the diagram is a generalization of well-known types such as ROBDD, MTBDD, and SBDD.
The theoretical considerations serve as a base for the technology mapping algorithms. The papers present a number of results obtained from experiments. The experiments were carried out for the commonly used benchmarks, applying various families of programmable logic devices (CPLD and FPGA). The designed technology mapping strategies were compared with other algorithms.

A. Pawlak (PhD), *Dependable medical cyber-physical system for home telecare of high-risk pregnancy*

Cyber Physical Systems (CPS) constitute a new generation of intelligent systems that are characterized by: a strong integration of devices and physical processes, device miniaturization, dramatic increase in a computational power of devices, lower demand for energy supply, sensing of the environment, new actuation possibilities, as well as ubiquitous communication. Many new applications in various domains are enabled by CPS. These in eHealth, and in particular in telemedicine, are among the most remarkable ones. Telemedicine is a new discipline that concerns use of clinical health care at a distance. A separate class of CPS, namely Medical Cyber Physical Systems (MCPSs) is recognized in the literature, as interconnected, intelligent systems of medical devices which support a holistic treatment of a patient. The inherent feature of MCPS is a conjunction of embedded software control of networked medical devices with complex safety- and often life-critical physical processes exhibited by patients' bodies.

The research aiming at contributions in the MCPS domain that is realized in close collaboration with the Institute of Medical Technology and Equipment (Prof. Janusz Jeżewski, ITAM, Zabrze) has one ultimate application, namely home-based telemonitoring of pregnant women. The envisioned system consists of the Body Area Network of advanced sensors that are interconnected on a body of a pregnant woman, as well as the Personal Area Network that is responsible for embedded processing of physical signals, smart alarms, and the transmission channel to the Surveillance Centre. Design of a dependable MCPS for telecare of pregnant women at home constitutes a challenging endeavour that requires a multidisciplinary research team. In 2015 design challenges and requirements, biosignals acquisition and Human-MCPS Interactions, have been objectives of a particular research attention. Additionally, efforts have been undertaken in building collaborative links.

DIVISION OF CIRCUIT AND SIGNAL THEORY

J. Konopacki (PhD, DSc), K. Mościńska (PhD), *One- and two-dimensional digital signal processing*

The main objective of the research was to develop design methods for digital filters. Digital finite impulse response (FIR) filters are often applied because of their numerous advantages, including inherent stability, well elaborated design methods and ease of obtaining a linear-phase response. Moreover, non-recursive structures can be easily implemented in programmable systems. A significant drawback of linear-phase FIR filters is large group delay, in particular when the order of the filter is large. In order to reduce group delay, the requirement for an exact linear phase can be restricted only to the passband. In many applications, such as communication systems, medical imaging, or active noise control systems, reduced group delays are required. For the design of such filters, methods dedicated for the broader category of nonlinear-phase filters design can be applied. One of the problems that appear while applying the given methods is calculation of the filter order. The authors proposed a new formula for the calculation of the filter order based on a prescribed group delay in the passband as well as other filter parameters (the width of the transition band and the magnitude response approximation error in the passband and stopband). The derivation has been shown for lowpass filters, and the procedure for other types of filters has been formulated. The elaborated formula enable less time to be spent on the design of a FIR filter. It can be also applied for the design of IIR filters based on the FIR prototype.

A. Pułka (PhD, DSc), Ł. Golly (PhD), A. Milik (PhD); *Modelling and simulation multitask time-predictable real-time systems*

The research relates to a very important issue of modern electronic embedded real-time systems concerning their repeatability and predictability. The proposed methodology is based on the high level abstraction tools - SystemC language. The authors proposed an approach based on the hardware threads interleaving in the pipeline processor core.

They developed an original architecture with a set of components responsible for appropriate processing of many threads (tasks) concurrently paying special attention to the elapsing time of the tasks. The most interesting scheduling mechanisms have been implemented in a dynamic controller of threads. The time-predictable architecture contains also a very efficient memory system based on the memory access control unit and dedicated memory system organization. Many simulation experiments conducted with a single and multi-core system architecture implementation allowed to obtain results that proved advantages of the presented model. A very important part of the work is described in Dr Golly's PhD thesis.
The most important results of the investigations are:

- introduction of temporary decoupling of threads into time-predictable systems. The model allows to control the timing of tasks without clock synchronization;
- development of the memory access controller module. This solution enables pipeline communication concurrent with the processor to the data memory and pipeline processing is more effective and predictable,
- elaboration of a few arbitration schemes that analyze tasks' deadlines and other important practical factors connected with tasks evaluation. The proposed scheduling mechanisms allow better use of the system resources.

DIVISION OF TELECOMMUNICATION

P. Zawadzki (PhD, DSc), *An analysis of the noise impact on the security of the quantum cryptographic protocols*

One of the greatest obstacles which stand in the way to construct unconditionally secure quantum cryptographic systems is the impact of the environment on a physical system implementing the quantum process. The entanglement of signalling particles and the environment, which occurs spontaneously in technical systems, is extremely difficult to avoid. The resulting decoherence of quantum states representing the transmitted information inevitably induces quantum errors. Activities of the attacker who interferes with the protocol execution cause also inevitably errors, and therefore, they are perceived by the communicating parties as additional noise. Therefore, the provision of methods (protocols) that provide tools for estimating and monitoring the error rate is the key issue of secure quantum communication.
Within the project, we carried out research on the development of methods of security analysis of cryptographic protocols in the presence of noise. One of the main initial assumptions was the universality of the method so it can be applied without any changes to the analysis of the protocols of different kind: direct quantum communication, quantum secret sharing and secure distributed quantum computing. Objectives of the research have been successfully completed. We proposed a method of estimating the quantum error rate based on measurements of the state of the particle in mutually unbiased bases. The usefulness of the method has been demonstrated for the ping-pong communication paradigm – a flagship implementation of the quantum direct communication.

L. Dziczkowski (PhD, DSc), G. Tytko (MSc), *E-cored Coil With a Circular Air Gap Inside the Core Column Used in Eddy Current Testing*

The mathematical model of an axially symmetric E-cored coil with a circular air gap inside the core column has been elaborated. This coil, which is located above a two-layered conductive half-space and is fed with an alternating current, is used as an eddy current probe. The Truncated Region Eigenfunction Expansion (TREE) method is used to obtain expressions describing the magnetic vector potential of the filamentary coil as a series with a finite number of summation terms and then written using matrix notation. The solution domain of the problem is truncated radially and discrete eigenvalues are computed from the boundary equations. The final expressions for the impedance of the rectangular cross-section coil have been obtained and calculations for various frequency values have been carried out. The results of the TREE calculations for an E-cored coil and an air-cored coil have been compared with those from the COMSOL Multiphysics package (based on the Finite Element Method), which shows very good agreement. The difference between the results obtained for the E-cored coil containing a circular air gap and the one without such an air gap has been determined. The aim of the research was to create an analytical model of the eddy current probe, which provides high sensitivity of the conductometer and flaw detector. The proposed solution may improve the process of calibrating eddy current devices.

DIVISION OF BIOMEDICAL ELECTRONICS

Prof. J. Łęski, M. Kotas (PhD, DSc), *Hierarchical Clustering with Planar Segments as Prototypes*

Clustering methods divide a set of observations into groups in such a way that members of the same group are more similar to one another than to the members of the other groups. One of the scientifically well known methods of clustering is the hierarchical agglomerative one. For data of different properties different clustering methods appear favorable. If the data possess locally linear form, application of planar (or hyperplanar) prototypes should be advantageous. However, although a clustering method using planar prototypes, based on a criterion minimization, is known, it has a crucial drawback. It is an infinite extent of such prototypes that can result in addition of very distant data points to a cluster. Such distant points can considerably differ from the majority within a cluster. The goal of this work is to overcome this problem by developing a hierarchical agglomerative clustering method that uses the prototypes confined to the segments of hyperplanes. In the experimental part, we show that for data that possess locally linear form this method is highly competitive to the method of the switching regression models (the accuracy improvement of 24%) as well as to other well-known clustering methods (the accuracy improvement of 16%). We have shown that the maximum density of planar segment linkage can be a useful alternative to the other definitions of the distance between merged clusters. The method of agglomerative hierarchical clustering based on this linkage allows the user to describe easily the distribution of the

data groups with the segments of hyperplanes in every stage of clustering. In contrast to the method of fuzzy switching regression models, the method proposed confines the extent of the planar prototypes. The comparison of the hierarchical clustering based on maximum density of planar segment linkage with the traditional switching regression models reveals that the former method prevails in clustering the data with planar distribution. Moreover, it allows for more effective accomplishment of practical tasks from the field of signal processing, such as determination of the signal characteristic points. It has also been shown that for real high-dimensional data the method proposed allows to detect the internal data structure and to model the data with smaller errors than with the use of the hierarchical clustering with point prototypes.

T. Pander (PhD, DSc), *A new approach to robust, weighted signal averaging*

In this work, a new approach to robust weighted averaging of time-aligned signals is proposed. Suppression of noise in such a case can be achieved with the use of the averaging technique. The signals are time-aligned and then the average template is determined. To this end, the arithmetic mean operator is often applied to the synchronized signal samples or its various modifications. However, the disadvantage of the mean operator is its sensitivity to outliers.
The weighted averaging operation can be regarded as a special case of clustering. For that reason in this work the averaging process is formulated as the problem of certain criterion function minimization and a few different cost functions are employed. This work presents a family of robust cost functions, based on the Generalized Cauchy (GC) distribution, which are applied to develop a new approach to robust weighted averaging methods based on the criterion function minimizing. The proposed approach allows to create at least two special cases of the cost functions, i.e. the myriad and the meridian ones. The robustness of the proposed methods can be controlled either with a single parameter (for the myriad and the meridian based methods) or with two parameters (in the case of the GC method). Such an approach allows to suppress various types of impulsive noise.
The proposed methods are applied to electrocardiographic cycles averaging. The proposed methods performance is experimentally evaluated and compared to the reference methods. There is presented a performance comparison of all described methods using the ECG cycles obtained from the PTB diagnostic ECG database as well as the muscle artifacts from the MIT-BIH noise stress test database (MA record) and the synthetic impulsive noise modelled with the symmetric α-stable distributions. Three patterns of simulation experiments are proposed to evaluate the respective methods. The best capability of the impulsive noise suppression (the smallest value of RMSE) in majority of cases has the method based on the generalized Cauchy distribution cost function. The obtained results show the usefulness of the presented GC weighted averaging method for time aligned signals like in the case of quasi-periodic electrocardiographic signal processing. The presented methods can help to improve averaging of time-aligned signals when the number of signals is small, the data are highly non-stationary and the signals are disturbed by an impulsive noise.

M. Jeżewski (PhD), R. Czabański (PhD), Prof. J. Łęski, *An attempt to optimise the cardiotocographic signal feature set for fetal state assessment*

Cardiotocographic (CTG) monitoring is a popular biophysical method for the fetal state assessment during pregnancy and labor. It consists in acquisition and analysis of fetal heart rate (FHR), uterine contractions and fetal movements signals. Visual interpretation of recorded signals is characterized by a high intra- and inter-observer variability, so computerized fetal monitoring systems offering automated signal analysis are frequently used. Computational intelligence methods are applied to assist in fetal state assessment based on the quantitative parameters describing the CTG signals. In case of classification methods, the assumed feature set influences the classification quality. In the presented work we studied the influence of three feature selection methods on the quality of the CTG signals classification for the fetal state assessment. The influence of the ambiguous cases on the classification quality was also investigated.
During the research we used the dataset of the CTG signals assessed by experts and assigned to three classes of the fetal state: normal, suspicious and abnormal. To classify the data we applied the Lagrangian support vector machine. Two approaches to the three-class classification (class-class and two-stage), and three variants of the two-class classification (three interpretations of the 'suspicious' class: excluded, assumed as abnormal and assumed as normal) were investigated. To study the influence of the feature selection methods on the classification quality we used three feature selection methods based on: principal component analysis, receiver operating characteristics and FIGO guidelines. The highest classification quality was, however, observed when all available features were used. The results of our research showed, that any attempt at reducing the number of the analyzed features must be carefully verified, especially in case of medical applications. The applied dataset included ambiguous cases – with the same features values and belonging to the same class (repeated cases), or to different classes (contradictory cases). To investigate the influence of the ambiguous cases on the classification quality we conducted the learning procedures with and without such cases. The differences in the classification quality obtained in that part of the research were irrelevant, regardless of the number of the ambiguous cases.

DIVISION OF MICROELECTRONICS AND NANOTECHNOLOGY

M. Kwoka (PhD), M. Krzywiecki (Ph.D)(Centre for Science and Education, Institute of Physics), *Rheotaxial growth and vacuum oxidation – novel technique of tin oxide deposition – in situ monitoring of oxidation process*

In this work a novel preparation method of SnO_2 nanolayers based on in situ rheotaxial growth and vacuum oxidation (RGVO) is presented for the first time in the literature. The SnO_2 films were characterized by using the X-ray Photoelectron Spectroscopy (XPS), and Atomic Force Microscopy (AFM) methods. A special emphasis was given to control the oxidation conditions in order to obtain the RGVO SnO_2 nanolayers of

controlled stoichiometry/nonstoichiometry for potential application as the oxidizing/reducing toxic gases sensors. The performed XPS studies demonstrated that the RGVO SnO_2 nanolayers are of extremely high purity and exhibit the controlled nonstoichiometry depending on the additional controlled oxidation. The variations of RGVO SnO_2 nanolayers' surface chemistry, determined by the XPS method, was in a good correlation with the variation of their surface morphology controlled by AFM experiments.

E. Wróbel (PhD), P. Kowalik (PhD), J. Mazurkiewicz (PhD)(Institute of Engineering Materials and Biomaterials, Silesian University of Technology), *Selective metallization of solar cells*

The aim of this research project was to develop a technology of chemical metallization for the production of contacts of photovoltaic cells that allowed to create low-cost contacts of any form. In our study we used multi- and monocrystalline silicon plates. Contacts were made on the surface of these plates by the process of electroless metallization. After the metallization stage, the annealing process in a temperature range of 100÷700°C was conducted to obtain an ohmic contact in the semiconductor material. Then, electrical parameters of the obtained structures were measured. Finally, trial soldering was made, which demonstrated that the layer is fully solderable.
As a result of our work optimal parameters of the metallization bath have been specified. The equations showing how the surface resistance depends on the metallization time and the temperature of annealing, as well as the C-V characteristics were determined. It has been stated that the most appropriate way leading to the production of solderable metal layers with good adhesion to the portion of a selectively activated silicon plate is the technology consisting of the following steps: masking, selective activation and nickel-plating of the activated plate. Such obtained metal layers have a variety of applications and, in particular, can be used for the preparation of electric terminals in silicon solar cells.