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

Annual Review 2017

Institute of Electronics

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Natalia Waczyńska-Niemiec

Institute of Electronics, March 2018

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 about 22,000 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 2,700 now. The Institute of Electronics is one of the three institutes in the faculty. Its history dates back to the early 1950s, when Chair of Electronics was created at the Faculty of Electrical Engineering and headed by Professor Adam Zagajewski, one of the pioneers of Polish electronics. The Institute of Electronics was created in 1974 and since then it has undergone a number of reorganisations. Now it has almost 70 members of academic staff and consists of six units:

- ***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***
- ***Group for 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 courses such as Printed Circuit Board Design (run in cooperation with Mentor Graphics), postgraduate courses, e.g. Programmable Electronic Circuits and Systems, and PhD studies in Electronics.

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
(until 31 August 2017)
Prof. Dariusz KANIA
(since 1 September 2017)

Vice Director of the Institute for Research:

Assoc. Prof. Zdzisław FILUS

Vice Director of the Institute for Teaching:

Asst. Prof. Jacek KONOPACKI

DIVISION OF ELECTRONICS FUNDAMENTALS AND RADIO ENGINEERING

Head of Division: Assoc. Prof. Zdzisław Filus

Research staff

Prof. Zdzisław FILUS, PhD, DSc

Prof. Andrzej KARWOWSKI, PhD, DSc
(until 30 September 2017)
Prof. Zbigniew RYMARSKI, PhD, DSc
Krzysztof BERNACKI, PhD
Andrzej BŁONAROWICZ, PhD
(until 30 September 2017)
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
Łukasz DYGA, MSc

Research fields

- Analysis and synthesis of analogue electronic circuits
- Symbolic methods of analysis of electronic circuits
- 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
- Materials Technology and Electronic Equipment Design
- Field and Wave Electromagnetics
- Introduction to Radiocommunication
- Radio Engineering Systems
- Antennas and Propagation of Electromagnetic Waves
- Wireless Computer Networks
- Design of Radio Electronic Devices
- High-Frequency Engineering Fundamentals
- Microwave Engineering
- Modulation, Conversion and Transmission of Signals
- Electromagnetic Compatibility
- Optoelectronics
- Optical Fiber Techniques

DIVISION OF DIGITAL AND MICROPROCESSOR SYSTEMS

Head of Division: Prof. Dariusz Kania

Research staff

Prof. Dariusz KANIA, PhD, DSc

Prof. Edward HRYNKIEWICZ, PhD, DSc
Robert CZERWIŃSKI, PhD, DSc
Mirosław CHMIEL, PhD
Tomasz GARBOLINO, PhD
Józef KULISZ, PhD
Adam MILIK, PhD
Adam PAWLAK, 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 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)
- SAW gas sensors
  - Investigations of selected SAW-based sensor structures
  - Methodology of SAW gas sensor investigations
  - Dual delay line measurement method
  - Optically activated thin films structures on SAW gas sensors for the determination of chemical compounds in the air

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 (until 31 August 2017)
Asst. Prof. Jacek Konopacki, (since 1 September 2017)

Research staff

Prof. Jerzy RUTKOWSKI, PhD, DSc
Jacek KONOPACKI, PhD, DSc

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

PhD Students
Krzysztof HANZEL, MSc
Krzysztof PASZEK, MSc
Paweł RYBKA, MSc
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
- Fundamentals of Electrical Engineering
- Fundamentals of Signal Processing
- Information Theory and Coding
- Computer-Aided Design of Electronic Circuits
- Digital Signal Processing
- System Level Modelling and Design
- Mixed Analog-Digital Circuits Design
- STM32 Family ARM Microcontrollers Programming
- Neural Networks
- LabView – Graphical Programming Language
- Computer-Based Measurements with NI LabView

DIVISION OF TELECOMMUNICATION

Head of Division: Asst. Prof. Jacek Izydorczyk

Research staff

Jacek IZYDORCZYK, PhD, DSc

Leszek DZICZKOWSKI, PhD, DSc
Piotr ZAWADZKI, PhD, DSc
Adam DUSTOR, PhD
Grzegorz DZIWOKI, PhD
Piotr KŁOSOWSKI, PhD
Marcin KUCHARCZYK, PhD
Wojciech SUŁEK, PhD
Jerzy WOJTUSZEK, PhD
(until 30 September 2017)

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

Research staff

Prof. Jacek ŁĘSKI, PhD, DSc

Prof. Monika KWOKA, PhD, DSc
Prof. Jacek SZUBER, PhD, DSc
Marian KOTAS, PhD, DSc
Tomasz PANDER, PhD, DSc
Ewa STRASZECKA, PhD, DSc
Robert CZABAŃSKI, PhD
Jerzy IHNATOWICZ, PhD
Michał KOZIELSKI, PhD
(until 30 September 2017)
Michał JEŻEWSKI, 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
  - Medical information systems
  - 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

- Nanotechnology of transparent conductive oxides and organic semiconductors for application in photovoltaics and gas sensors

Courses

- Electromedical Metrology
- X-ray and Nuclear Imaging
- 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
- Fundamentals of Physics
- Electronics for Environment

GROUP FOR MICROELECTRONICS AND NANOTECHNOLOGY

Head of Group: Asst. Professor Krzysztof Waczyński

Research staff

Krzysztof WACZYŃSKI, PhD, DSc

Wojciech FILIPOWSKI, PhD
Weronika IZYDORCZYK, PhD
Piotr KOWALIK, PhD
Jerzy ULJANOW, PhD
Edyta WRÓBEL, PhD

Research fields

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

Courses

- Design of Thick/Thin-Film Circuits
- Diagnostic Methods in Microelectronics and Nanotechnologies
- Electronic Devices, Semiconductor Structures and Circuits
- Fundamentals of Electrical Engineering, Measurements and Electronics
- Hybrid Circuit Technology
- Information Technologies
- Materials Science and Principles of Construction of Electronic Equipment
- Microelectronics
- Microelectronics Technology
- Modelling of Phenomena and Structures in Microelectronics and Nanotechnologies
- Nanotechnology in Microelectronics
- Photovoltaics
- Sensor Arrays
- Sensors and Actuators
- Solid State Electronics
- Thick-Film Technology
- Thin-Film Technology

SECRETARIAL AND TECHNICAL STAFF

Secretarial staff

Beata BIELAWNY, MBA
Agata CUDAK-TUTAJEWICZ, MSc
Tatiana NIEDZIELA, BBA

Technical staff

Andrzej CZYŻ, MSc
Dariusz KOLKA, MSc
Łucja LEWANDOWSKA
Szymon PARA, MSc
Tomasz SZYMAŃSKI, BSc
Natalia WACZYŃSKA–NIEMIEC, MSc
Jarosław WROTNIAK, MSc
Piotr ZAJĄC, BSc
Czesław ZIOBER

STATUTORY ACTIVITIES OF THE INSTITUTE OF ELECTRONICS

DSc DEGREES CONFERRED ON STAFF MEMBERS OF THE INSTITUTE OF ELECTRONICS

1. **Robert Czerwiński** – DSc degree conferred on the basis of a series of publications entitled "Methods of FSMs logic synthesis and technology mapping for PAL-based programmable structures", the Faculty of Automatic Control, Electronics and Computer Science, Silesian University of Technology, 28 November 2017

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

2. **Krzysztof Bąk,** Testing NAND FLASH storage devices in the production process, PhD advisor: Asst. Prof. Dariusz Badura (WSB Dąbrowa Górnicza), 09 May 2017
3. **Tomasz Moroń,** Application of dynamic nonlinear alignment in the processing of biomedical signals, PhD advisor: Asst. Prof. Marian Kotas, 21 November 2017

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, systems and objects radiating and dissipating electromagnetic waves - 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 technology enhanced teaching*

Division of Telecommunication:

- *Development of methods and applications of digital channel commutation and processing and transmission of digital signals*

Division of Biomedical Electronics:

- *Acquisition and processing of biomedical information*

Group for Microelectronics and Nanotechnology:

- *Advanced technology in microelectronics and nanoelectronics*

In total, 33 individual research projects were completed in 2017.

RESEARCH GRANTS AWARDED BY NATIONAL SOURCES

1. 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.

2. Dynamic properties of voltage source inverters with impedance networks, supplied from low DC voltage, taking into account the real parameters of the soft magnetic materials. (PRELUDIUM 9) 2015/17/N/ST7/03720.
Period: March 2016-September 2018
Coordination: K. Bernacki, PhD
Scientific advisor: Prof. Z. Rymarski
The description of the small signal models of voltage source inverters for UPS systems, in relation to the influence of DC/DC step-up input voltage converters (impedance networks) is the main research project target. The influence of changes of the magnetic materials parameters of the cores for coils and transformers will be implemented in the models. The analysis will concern single-phase small and medium power (<4kVA) inverters. The small-signal models will be used in the design of the digital robust control of inverters that fill the requirements of the required standards that limit the output voltage distortions of UPS devices for static and dynamic, linear and nonlinear loads. The generalized methodology of a voltage source inverter design based on using the created models of the single-phase low and medium power inverters will be the final result of the project.

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 - 31.10.2017.
Coordination: T. Garbolino, PhD
The main objective of the grant is to prepare the whole documentation that is required in the process leading to the postdoctoral 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.

4. Novel type of gas sensor of toxic gases based on surface photovoltage effect. Project financed by the National Science Centre: OPUS11 - No. 2016/21/B/ST7/02244
Period: 2017-2020
Principal investigator: Prof. M. Kwoka
The aim of this project is elaboration of a novel type gas sensor based on the surface photovoltaic (SPV) effect in the space charge layer of selected nanostructured conductive oxides for faster detection of toxic gases already at room temperature. A rather long response time, despite the quite good sensitivity and selectivity of currently available conductometric gas sensors, looks as one of the main limitations in future progress of this field, including the most spectacular commercial system for detection of gases like an electronic nose. Therefore, our SPV gas sensor device can be treated as an evident contribution to the progress of novel type toxic gas sensory devices for better control and then elimination of environmental contaminations, allowing improvement of human living conditions.

6. Optimization of technology of preparation of tin dioxide SnO_2 nanolayers of maximal extension of internal surface for gas sensor application. Project financed by the National Science Centre: FUGA5 - No. 2016/20/S/ST5/00165
Period: 2016-2019
Principal investigator: B. Łysoń-Sypień, PhD
Participant: Prof. M. Kwoka
The aim of this project is an optimization of two methods of preparation of SnO_2 nanolayers for their potential gas sensor application. The first one consists in deposition of SnO_2 nanolayers onto the Si substrate using

thermal evaporation of SnO_2 powder combined with subsequent thermal oxidation under ultra high vacuum conditions (TEVO). In turn, the second one uses the rheotaxially grown Sn nanolayers deposited onto the Si substrate in the form of almost isolated nanodroplets, which undergo then thermal oxidation to the tin dioxide SnO_2 nanolayers at dry oxygen exposure under the ultrahigh vacuum conditions (RGVO). Both TEVO and RGVO technological approaches will allow us to obtain SnO_2 nanolayers consisting of almost isolated nanograins, what assures the highest extension of their internal surface, and thus allows fast and direct contact of gas with the appropriate adsorption centers inside the deposited SnO_2 nanolayers.

INTERNATIONAL CO-OPERATION

1. Brandenburg University of Technology, Cottbus, Germany (Dr A. Pawlak, Dr A. Pułka, Prof. E. Hrynkiewicz)
2. Brno University of Technology, Faculty of Electrical Engineering and Communication, Department of Control and Instrumentation, Czech Republic (Dr A. Milik, Prof. E. Hrynkiewicz)
3. Technical University of Ostrava, Faculty of Electrical Engineering and Computer Science, Department of Measurements and Control, Czech Republic, (Prof. E. Hrynkiewicz)
4. University of Brescia, Italy (Prof. J. Szuber, Prof. M. Kwoka)
5. Universidad Tecnológica de Bolívar Cartagena, Colombia (Dr M. Kotas)

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

International

1. **Dr T. Garbolino**, Steering Committee and Program Committee, 20th IEEE Symposium on Design and Diagnostics of Electronic Circuits and Systems, (DDECS 2017), 19-21 April 2017, Dresden, Germany
2. **Prof. E. Hrynkiewicz**, Steering Committee and Program Committee, 20th IEEE Symposium on Design and Diagnostics of Electronic Circuits and Systems, (DDECS 2017), 19-21 April 2017, Dresden, Germany

3. **Prof. E. Hrynkiewicz**, Program Committee, 13th IEEE International Conference: Beyond Databases, Architectures and Structures (BDAS 2017), 30 May - 2 June 2017, Ustroń, Poland
4. **Prof. E. Hrynkiewicz**, Program Committee, 24th International Science Conference on Computer Networks (CN 2017), 20-23 June 2017, Stonemount Castle, Lądek Zdrój, Poland
5. **Prof. D. Kania**, Program Committee, 21th International Conference Electronics 2017, 19-21 June 2017, Palanga, Lithuania
6. **Prof. D. Kania**, Session Organizer, 13th International Conference of Computational Methods in Science and Engineering, (ICCMSE 2017), 21-25 April 2017, Thessaloniki, Greece
7. **Prof. D. Kania**, Scientific Committee, 9th International Conference on Computational Collective Intelligence, 27-29 September 2017, Nicosia, Cyprus
8. **Dr P. Kłosowski**, Program Committee, International Symposium on Engineering Education and Educational Technologies, (EEET 2017), 8-11 July 2017, Orlando, Florida, USA
9. **Dr P. Kłosowski**, Program Committee, International Multi-Conference on Engineering and Technological Innovation, (IMETI 2017), 8-11 July 2017, Orlando, Florida, USA
10. **Dr J. Kulisz,** Session Organizer, 13th International Conference of Computational Methods in Science and Engineering, (ICCMSE 2017), 21-25 April 2017, Thessaloniki, Greece
11. **Dr A. Pawlak**, Steering Committee and Program Committee, 20th IEEE Symposium on Design and Diagnostics of Electronic Circuits and Systems, (DDECS 2017), 19-21 April 2017, Dresden, Germany
12. **Dr A. Pawlak**, Program Committee, 20th Euromicro Conference on Digital System Design (DSD17), 30 August - 1 September 2017, Vienna, Austria
13. **Dr A. Pawlak**, PC member, 18th IFIP Working Conference on Virtual Enterprises - Collaboration in a Data-Rich World (PRO-VE 2017), 18-20 September 2017, Vicenza, Italy
14. **Dr A. Pawlak**, 12th International Scientific and Technical Conference Computer Science and Information Technologies, (CSIT-2017), 5-8 September 2017, Lviv, Ukraine

15. **Prof. J. Rutkowski**, Program Committee, 4th International KES Conference on Smart Education and E-Learning (KES-SEEL-17), 21-23 June 2017, Algarve, Portugal
16. **Prof. J. Rutkowski**, Scientific Committee, 24th International Conference on Mixed Design of Integrated Circuits and Systems (MIXDES), 22-24 June 2017, Bydgoszcz, Poland
17. **Dr W. Sułek**, Technical Program Committee, 40th International Conference on Telecommunications and Signal Processing (TSP 2017), 5-7 July 2017, Barcelona, Spain
18. **Dr K. Waczyński**, Scientific Committee, 41th International Microelectronics and Packaging Poland Conference (IMAPS 2017), 11-13 September 2017, Warsaw, Poland

National

1. **Prof. Z. Filus**, Scientific Committee, 16th National Electronics Conference, 5-9 June 2017, Darłowo
2. **Prof. E. Hrynkiewicz**, Scientific Committee, 20th Conference on Reconfigurable Ubiquitous Computing, (RUC 2017), 25 May 2017, Szczecin
3. **Prof. E. Hrynkiewicz**, Scientific Committee, 16th National Electronics Conference, 5-9 June 2017, Darłowo
4. **Prof. D. Kania**, Scientific Committee, 20th Conference on Reconfigurable Ubiquitous Computing, (RUC 2017), 25 May 2017, Szczecin
5. **Prof. A. Karwowski**, Scientific Committee, National Conference on Radiocommunications and Broadcasting, 21-23 June 2017, Poznań
6. **Dr A. Milik**, Scientific Committee, 20th Conference on Reconfigurable Ubiquitous Computing, (RUC 2017), 25 May 2017, Szczecin
7. **Prof. J. Rutkowski**, Scientific Committee, 16th National Electronics Conference, 5-9 June 2017, Darłowo
8. **Prof. J. Szuber,** Scientific Committee, 8th National Conference on Nanotechnology (KKN), 20-23 June 2017, Łódź
9. **Prof. J. Szuber,** Scientific Committee of 11th Conference of Vacuum Technique of the Polish Vacuum Society (PVS), 25-28 September 2017, Cedzyna

REVIEWERS

1. **Dr K. Bernacki**, International Journal of Circuit Theory and Applications, International Journal of Electronics, IEEE Transactions on Power Electronics
2. **Dr Ł. Chruszczyk**, Circuits, Systems, and Signal Processing Journal (Springer), Engineering Science and Technology, an International Journal (JESTECH) (formerly Technology) (Elsevier), 25th IFIP/IEEE International Conference on Very Large Scale Integration (VLSI-SoC 2017)
3. **Dr R. Czerwiński,** International Journal of Applied Mathematics and Computer Science, IEEE Transactions on Industrial Electronics, IEEE Transactions on Power Electronics, Elektronika ir Elektrotechnika
4. **Dr G. Dziwoki,** IEEE Transactions on Wireless Communications, IEEE Transactions on Vehicular Technology
5. **Dr W. Filipowski**, Elektronika - Konstrukcje Technologie Zastosowania, Archives of Metallurgy and Materials, Circuit World
6. **Prof. Z. Filus**, International Journal of Electronics, National Electronics Conference
7. **Dr T. Garbolino**, 20th IEEE Symposium on Design and Diagnostics of Electronic Circuits and Systems - DDECS 2017, 20th EUROMICRO Conference on Digital System Design - DSD 2017 (special session), 25th IFIP/IEEE International Conference on Very Large Scale Integration - VLSI-SoC 2017
8. **Dr T. Golonek**, Journal of Electronic Testing-Theory and Applications (JETTA, Springer), 24th International Conference on Systems, Signals and Image Processing (IWSSIP 2017), 25th IFIP/IEEE International Conference on Very Large Scale Integration (VLSI-SoC 2017)
9. **Dr D. Grzechca**, Journal of Electronic Testing: Theory and Applications, Circuits, Systems & Signal Processing, Metrology and Measurement Systems, Circuit Systems and Signal Processing, International Journal of Electronics and Telecommunication
10. **Prof. E. Hrynkiewicz**, Journal of Circuits, Systems and Computers; IEEE Transactions on Industrial Electronics, IEEE DDECS Symposium, 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 19th Conference on Reconfigurable Ubiquitous Computing (RUC 2017), Associate Editor for IFAC World Congress in the frame of IFAC TC 4.1.

11. **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
12. **Prof. D. Kania**, Bulletin of the Polish Academy of Sciences – Technical Sciences, IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, Journal of Information and Telecommunication, 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 on Systems, Signals and Image Processing, International Conference of Computational Methods in Science and Engineering, International Conference Electronics 2017, International Symposium on Applied Reconfigurable Computing, Przegląd Elektrotechniczny, Studia Ekonomiczne – Zeszyty Naukowe
13. **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)
14. **Dr P. Kłosowski**, International Symposium on Engineering Education and Educational Technologies, EEET 2017, International Multi-Conference on Engineering and Technological Innovation, IMETI 2017, support in the reviewing process of the Bulletin of the Polish Academy of Sciences: Technical Sciences in 2017, support in the reviewing process of Electronic Letters, support in the reviewing

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15. **Dr J. Konopacki**, 24th International Conference on Systems, Signals and Image Processing, IWSSIP 2017, 16th International Conference on Artificial Intelligence and Soft Computing ICAISC 2017
16. **Dr M. Kotas**, Medical Engineering & Physics, IEEE Transactions on Biomedical Engineering, Biomedical Signal Processing and Control, Biocybernetics and Biomedical Engineering, Computers in Biology and Medicine, Editorial Board of International Journal of Information and Electronics Engineering
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18. **Dr A. Kristof,** Circuits, Devices & Systems, Mathematics and Computers in Simulation
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21. **Dr A. Milik**, CIRP Conference on Manufacturing Systems, Elsevier - Control Engineering Practice, World Scientific - Journal of Circuits, Systems and Computers
22. **Dr T. Pander**, Recent Advances in Electrical and Electronic Engineering, Biomedical Signal Processing and Control, IEEE Transactions on Biomedical Engineering, Innovations in Biomedical Engineering (IiBE 2017), International Conference on Man-Machine Interactions 2017
23. **Dr A. Pawlak,** European Commission project proposals (Call H2020 FOF-10-2017), ECSEL Joint Undertaking - "Electronic Components and Systems for European Leadership" project proposals (Call H2020-ECSEL-2017-2- two-stage), Monitoring for the European Commission a running project from the Call H2020-FOF-2016, Elsevier Journal MICPRO- Microprocessors and Microsystems, Journal of Medical

Informatics & Technologies, “Continuous adaptation of work environments with changing levels of automation in evolving production systems” H2020-IND-CE-2016-2017

24. **Dr A. Pułka**, Interdisciplinary Sciences: Computational Life Sciences, Journal of Experimental & Theoretical Artificial Intelligence, ACM Journal of Experimental Algorithms, IET Circuits, Devices & Systems
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29. **Dr T. Topa**, International Journal of Numerical Modelling: Electronic Networks, Devices and Fields; IEEE Antennas and Wireless Propagation Letters, IET Science, Measurement and Technology
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31. **Dr D. Wójcik**, Progress in Electromagnetics Research
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Prof. J. Rutkowski was awarded for outstanding overall professional achievements by the Minister of Science and Higher Education

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ABSTRACTS OF SELECTED RESEARCH PROJECTS

DIVISION OF ELECTRONICS FUNDAMENTALS AND RADIO ENGINEERING

Prof. Z. Rymarski, K. Bernacki (PhD), Ł. Dyga (MSc), *Measuring real parameters of single-phase voltage source inverters for UPS systems*

Design of a control system for a voltage source inverter (VSI) requires knowledge about its continuous or discrete model. The output filter inductance and the equivalent serial resistance, which is partly the result of power losses in the core, have values at the operating point that are significantly different from the assigned nominal values, particularly for iron-powder cores. Measurements using standard laboratory equipment are not sufficient because it is impossible to get the voltage and current of the operating point. The frequency domain identification of a VSI is required in the design process of its control system. The best solution is to measure the Bode plots of the inverter control function at the operating point, to estimate the results of the measurements using the proper analytic function and to calculate real values of the inverter parameters. Knowledge about the equivalent serial resistance enables the estimation of the inverter power losses. Two approaches to measurements were shown – one that does not require any additional equipment and the other that uses a specialised system to automatically measure the Bode plots. The advantages and disadvantages of both approaches were presented. The idea of relative measurements allows the problem of the non-ideal characteristics of amplifiers to be corrected without having to deal with the polarity of the measurement path. Although both methods result in satisfactory magnitude plots, the second method, which uses a specialised control system, gives a much more credible phase plot for the frequencies over the resonant frequency. The exact phase shift measurement permits the Matlab 'oe' function to be used for a high load and a high damping coefficient. These measurements enable the validation of the coil core magnetic material by taking into account the power losses. The coil with a core made of the worst iron-powder Material Mix No. -26 can change its inductance 1.5 times and its equivalent serial resistance R_{LFe}, which mainly results in power losses in the core that are three to four times higher than for coils with cores made of high quality alloy-powder magnetic materials. The measurements enabled to choose the best material in the presented application at the same temperature with the same switching frequency (Optilloy-Micrometals). However, a much cheaper alloy-powder (e.g. Super-MSS – Micrometals) has almost the same parameters (low power losses and the inductance close to the nominal). Using the most expensive materials (FluxSan, Molypermalloy, Hi-Flux) did not result in better coil parameters. The frequency of the excitation in the 50-5000 Hz range did not change the coil parameters because of the dominant influence of the switching frequency. Two examples of MISO control systems designed with the measured parameters of the output filter coils were presented.

Z. Kidoń (PhD), Prof. D. Kania, J. Fiołka (PhD), T. Łukaszewicz (MSc), *Parametrization of the COP trajectories obtained during visual feedback posturography*

The main goal of the research was to find clinically applicable measures of posture based on the analysis of the COP (Center of Pressure) trajectories registered during the visual feedback posturography.
The visual feedback posturography is a diagnostic approach in which the subject - standing on a posturographic platform - performs visually stimulated swaying movements of his or her body. A type of examination implementing such an approach is the so-called follow-up posturography - characterised by the application of the clockwise and counter-clockwise visual stimuli which are mutually symmetrical from the perspective of the left and right lower limb. This kind of diagnostics can be a source of valuable information as far as the dynamics of the limb loading is concerned. It is worth noting that it can be realized resorting to a posturographic platform used for the purposes of static posturography.
In our research, special attention has been paid to the development of the COP parameters enabling postural symmetry evaluation. The first one quantifies similarity between the phase approximation of the counter-clockwise follow-up COP trajectory and the mirrored image of the phase approximation obtained for the clockwise trajectory, whereas the mirror image transformation is realized about the Y-axis. Postural symmetry evaluation in this approach is based on the assessment of the degree of intersection between the compared signals. The obtained coefficient quantifies postural symmetry with respect to „global" tendencies of the follow-up COP trajectories, minimising the influence of incidental COP displacements. The second of the devised postural symmetry measures relies upon covariances of the corresponding coordinates of the clockwise and counter-clockwise follow-up COP trajectories as well as on the so-called half-plane averaging of these signals. In this case the symmetry of posture is quantified in terms of instantaneous as well as average similarity of the registered follow-up COP trajectories. The third method of the postural symmetry assessment is based on Fourier analysis of complex-valued posturographic data. Usefulness of the proposed postural symmetry measures has been confirmed in the group of 30 patients rehabilitated after total hip arthroplasty.

J. Chęciński, Prof. Z. Filus, *Examination of the possibility of data transmission over LED lighting installations*

Today, lamps based on light-emitting diodes (LED) have been widely replacing conventional light sources such as incandescent or fluorescent lamps in general lighting installations. Thanks to high luminous efficiency (over 160lm/W) and lifetime exceeding 50,000 hours (with the still acceptable remaining luminous flux) they are the most energy saving and long lasting lighting sources. They also offer ease of dimming and changing the colour temperature of light. These features were tested by us in previous years.

Another feature of LEDs is very fast change in light intensity following the change of current flowing through the lamp. For lighting applications this is considered as a serious disadvantage due to flickering effect.
However, fast response of LEDs offers great opportunities in other areas. Due to the more and more widespread applications of devices that use wireless radio communication, it is possible to come to a point soon in which the limited resources of the available frequency bands will be exhausted. From this point of view, research focused on the development of alternative methods of signal transmission is becoming very important. Such transmission may be effected by proper modulation of the luminous flux of lamps used in lighting installations. LEDs allow particularly easy modulation of their luminous flux, even with a high frequency. This type of communication, using LED lighting, is usually referred to as Visible Light Communication (VLC). In our recent work on this topic we concentrated on examining the bandwidth offered for transmission by phosphor-based white LEDs and white lamps composed of RGB (Red-Green-Blue) lamps. The results of experiments have shown that phosphor-based LEDs can easily be modulated for sinusoidal excitation at frequencies reaching a few megahertz, while for RGB lamps useful frequencies reach tens of megahertz.

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*

The main goals of the project are reduced response time and increased throughput of the control system. The controllers design process utilizes standard languages enabling effortless technology change for designers and final users. The input programs are prepared according to IEC61131-3 and IEC61499. There are two main paths of control system implementation utilizing multi-core CPU architectures and direct in hardware implementation utilizing FPGAs. In the software implementation of control algorithms there are introduced multithreaded computation and perfectly fitted hardware architectures to particular tasks. The multi-core CPUs are delivered with several co-processing units (timers, counters, edge detectors) that significantly reduce computation requirements. Multithreaded program execution or direct hardware implementation is supported by an originally developed compiler enabling hardware-software co-design. It enables translation of an input program into a target independent form. The intermediate form is the originally developed graph representation with enhancements for representing and manipulating logic and arithmetic operations. Later this form is mapped to a given target platform, either generating instructions sequences or generating hardware structure. The direct hardware implementation enables massive parallel computation. The mapping algorithms enable generation of hardware structures with resource reuse. It balances resource requirements with extraordinary performance. It is able to achieve performance more than 100 times higher in comparison to the fastest commercially available PLCs CPU. It is important in the case of systems where

short response times are expected and a response is always generated in a predictable time period. The multicore-CPU mapping unit enables automatic program decomposition into parallelly executed threads and delivering balanced computation distribution with low overhead synchronization mechanisms.

J. Kulisz (PhD), Prof. D. Kania, R. Czerwinski (PhD, DSc), *Methods of logic synthesis orientated towards exploiting specific features of programmable logic devices*

The methods of logic synthesis for programmable logic devices were addressed. The methods are intended for combinational circuits and for Finite State Machines (FSMs) as well. The main ideas are: to control the clock input of flip-flop and to block the active edge of clock, to use binary decision diagrams (BDD) in order to perform functional decomposition for LUT-based devices.
One of the main aspects of logic synthesis dedicated to FPGA is the problem of technology mapping, which is directly associated with the logic decomposition technique. Current work focuses on using configurable properties of CLBs in the process of logic decomposition and technology mapping. A novel theory and a set of efficient techniques for logic decomposition based on a BDD have been proposed. It has been shown that logic optimization can be efficiently carried out by using multiple decomposition. The essence of the proposed synthesis method is multiple cutting of a BDD. A new diagram form called an SMTBDD has been proposed. Moreover, techniques that allow finding the best technology mapping oriented to configurability of CLBs have been described. In addition, an efficient technology mapping method of FSMs, dedicated for PAL-based PLDs has been proposed. The essence of the method consists in searching for the minimal set of PAL-based logic blocks that cover a set of multiple-output implicants describing the transition and output functions of an FSM. The method is based on a new concept of graph: the Graph of Excitations and Outputs.
The clock gating methods were examined in order to define new methods. A comparison of four methods of implementing sequential circuits in Programmable Logic Devices in respect of dissipated power was performed. The comparison was carried out using simple counter circuits, i.e. circuits the algorithm of which is described by linear graphs. However, the presented considerations are general, and can be applied to any sequential circuit. Results of simulation tests show that the method based on clock gating is the most efficient one, and it leads to significant reduction of the dissipated dynamic power. The authors also propose a simple modification of global clock network structures, to facilitate clock gating.
The designed strategies were examined by running experiments with commonly used benchmarks. The method of BDD-based decomposition (MultiDec) was compared with academic and commercial tools. The experimental results show that the proposed technology mapping strategy leads to good results in terms of the number of CLBs. The new concept of graph of excitations and outputs has also been examined and preliminary experiments prove the effectiveness of the method.

B. Wyrwoł (PhD), *Fuzzy logic controller*

The main goal of the research is analysis, synthesis and optimization of rule (FITA, First Inference Then Aggregate) and relational (FATI, First Aggregate Then Inference) classic and hierarchical models of fuzzy inference systems. These models can be implemented in programmable logic devices or microprocessor systems, but implementation of the hierarchical model allows to decrease hardware and software cost of the system and computation time of the inference result. The hierarchical fuzzy inference model consists of the SISO (Single Input Single Output) subsystems. They have the same simple architecture, but they differ in contents of its knowledge subbases in a form of knowledge base (fuzzy rules and definition of linguistic variables) or fuzzy relation for FITA and FATI inference systems respectively. The knowledge subbases describe the behavior of the SISO systems and they are created using the decomposition method. The decomposition method is based on a projection of the fuzzy relation of the primary fuzzy inference system and originally it was used only for FATI systems, but it has been also expanded for FITA systems (linguistic decomposition based on projection of the rule base). The classic decomposition method is based on projection, so the inference result in the hierarchical model can be more fuzzy than in the classical architecture. This is a consequence of the presence of the so-called decomposition error.
The models of the MISO (Multiple Input Single Output) fuzzy inference system are used in the developed programmable logic controller. The programmable logic controller is implemented both in software (AVR and ARM family microcontrollers, the program is written in C and assembler) and in hardware (Xilinx FPGA, description of the system is in Verilog) to check suitability of the fuzzy models in practical applications.
Tests of the controller were carried out in the target environment (closed-loop temperature control system). It was shown that the decomposition error influences control parameters (overshoot, setting time, steady state error). The parameters of the control system are deteriorated. The decomposition error minimization is based on: modification of the consequence part of the if-then rules (methods based on derivative linguistic values), partitioning the primary rule base (basic partitioning algorithms, canonical partitioning algorithm, methods using graph coloring algorithms) or tuning the scaling factor in the denormalisation module of the controller. In order to achieve high quality of control at low software or hardware cost of the system, the presented methods can be joined. Combining methods based on partitioning and derivative linguistic values gives very good implementation results and offers robust control.
The developed programmable logic controller with implementation of the hierarchical model of fuzzy system proves its suitability in real practical applications. Introduced optimizations and improvements allowed to reduce both system resource requirements and a computation time of the output result.

DIVISION OF CIRCUIT AND SIGNAL THEORY

T. Golonek (PhD), J. Machniewski (PhD), *Data mining and processing oriented to analog electronic circuits diagnosing*

The aim of this project has been the design of an algorithm for analog electronic circuits (AECs) diagnosing with a especial focus on the functional testing methodology. Finally, an approach for a quick verification of AECs specifications that is based on a simple mathematical model determined during the before test stage statistical analysis was proposed. Generally, the observed performance parameters (e.g. cut-off frequency, phase shift at the assumed frequency point) are calculated from the Walsh-Hadamard transform components of the circuit under test step time response. The optimal estimating formulas for the relationship between the tested specifications and the selected components of the spectra are defined in the system based on a linear multiple regression procedure supported by genetic programming. The evolutionary computations significantly improve the approximation effectiveness by selecting the most representative points of the sequences domain and by defining the optimal set of linearizing functions. Finally, at the test stage, only a simple step stimulus and time effective calculations are required to the tested performance parameters (specifications) of analog circuit identification and it predisposes the approach to quick production testing procedure realization or to embedding it in the mixed-signal systems. The automated built-in self-testing procedure using this concept may be easily implemented in a low cost microcontroller equipped with an AD converter used for the testing response samples acquisition. During the verification of the method effectiveness, the analog testing signatures were quantized to the discrete samples which represent 10 bits AD conversion and maximally about 80% of its scale value respectively. Despite this practically limited resolution of acquired samples, the proposed approach reaches high precision of performance parameters estimations and it was illustrated by means of comparison to the alternative techniques analysis. The results obtained in this way allow to conclude that the designed functional testing methodology is competitive to the referenced ones and it assures simple, cost effective and efficient verification of AECs condition.

D. Grzechca (PhD, DSc), P. Rybka (MSc), K. Paszek (MSc), *Enhanced reliability of ADAS sensors based on the supply current observation*

ADAS (Advanced Driver Assistance Systems) are essential parts for developing the autonomous vehicle concept. ADAS belong to Cyber-Physical Systems (CPS) which combine the real and digital worlds with the help of computational technologies using e.g. the internet infrastructure. ADAS cooperate with different on-board car equipment to make driving safe and comfortable. The team developed a methodology for monitoring ADAS behaviour and assess their reliability. The designed solution combines the versatility of applications (it can be used with almost any kind of sensors), low cost (data acquisition using this method requires only a simple electronic circuit)

and requires no adjustments of the sensor's software or hardware. Using the proposed analysis, one can determine the device's family, find any over- and under-voltages that can damage the sensor or even detect two-way CAN communication malfunctions. Since the data acquired is complex (and can be troublesome during processing) – one of the best solutions is to cope with the problem by using a variety of neural networks.

D. Grzechca (PhD, DSc), S. Temich (MSc), L. Chruszczyk (PhD), *Specification driven test for voltage controlled oscillator based on the fuzzy expert system*

In the field of analog and mixed signal electronic integrated circuits testing, a novel approach to the specification driven test has been designed. The fuzzy logic expert system for the specification test of a voltage controlled oscillator (VCO) - ring topology is applied. The expert system takes into account parametric fault models of CMOS transistors like channel length, width and oxide thickness. The method uses linguistic variables of input features in the premise section that allows to convert linguistic information into numeric values. The features are selected arbitrarily, however, it can be done with the use of a metaheuristic algorithm (e.g. genetic algorithm). The conclusion section is described with the Takagi-Sugeno type. The approach has been compared with a classic dictionary where the SVM method is the most often applied. Finally, the results prove high efficiency of the proposed method.

DIVISION OF TELECOMMUNICATION

P. Zawadzki (PhD, DSc), *Quantum cryptography*

Quantum communication encodes messages in the states of quantum objects which are further exchanged over the quantum communication channel. One of the greatest obstacles in construction of the quantum unconditionally secure cryptographic system is the impact of the environment on the physical system that represents a transferred message. The entanglement of signaling particles and the environment, which occurs spontaneously in technical systems, is impossible to avoid. The resulting decoherence of quantum states representing the transmitted information inevitably induces quantum errors. Activities of the malevolent eavesdropper are also perceived by the communicating parties as additional noise. Therefore, the provision of methods and protocols that provide tools for estimating and monitoring the error rate is the key issue of quantum cryptography. We carried out research on the estimation of the security level of quantum direct communication and quantum authentication protocols in the presence of noise. Quantum direct communication protocols provide confidentiality of sensitive information without any encryption, while quantum authentication permits verification of the information source. Protocols of this type frequently use entanglement to physically protect transmitted data and offer reasonable security in perfect quantum channels. However, it has been shown that they do not hold security in the presence of losses. We have identified the incomplete check of coherence as the source of the above mentioned weakness. Improved protocols detect attacks with high probability and

independently of the quantum channel type. The proposed solution has desired properties also in the regime of dense information coding. It is worth noting that invention of quantum communication protocols which behave well in imperfect channels is of key importance because the noise is rather a rule than an exception in a quantum world.

W. Sułek (PhD), *Nonbinary LDPC codes and their efficient hardware decoder implementation*

Binary Low Density Parity Check (LDPC) codes have been utilized as an effective forward error correction scheme in various wireless communication and information systems. The extension of binary LDPC codes to higher order fields GF(q) has shown to achieve an additional coding gain when using small to moderate codeword lengths, at the cost of increased decoding complexity. In consequence, the decoder hardware implementation as well as an implementation friendly code design is still a challenging task.
This research project concerns the nonbinary (NB) LDPC hardware coding system design approach, primarily targeted for the FPGA devices. We reformulate the mixed-domain FFT-BP decoding algorithm and develop a decoder architecture that does not exclude the multiplication units. This allows mapping a part of the algorithm to the multiplier cores embedded in an FPGA, thus making use of all the types of FPGA resources. Then, the throughput limit achievable in a single FPGA by the proposed decoder is significantly increased. We also consider another improvements of the decoder hardware implementation, that is an efficient realization of the permutation units, effective use of the pipeline processing, optimization of the message quantization scheme and an approximated evaluation of the nonlinear functions of messages.
Another motivation is to make the coding system robust and easily scalable for a broad range of throughputs required for different applications. To achieve this goal, the design methods for construction of implementation oriented codes with scalable parallelization of the associated decoder are developed. Particularly we propose an algorithmic design method for a subclass of structured NB-LDPC codes, efficiently encodable and decodable in hardware architectures. The developed construction method offers an unrestricted choice of the submatrix size as well as the other code parameters: the GF(q) order, the code rate and block length. Experimental results show that the constructed NB-LDPC codes outperform significantly the binary codes and offer a really effective coding scheme for a broad range of potential applications.

DIVISION OF BIOMEDICAL ELECTRONICS

M. Jeżewski (PhD), R. Czabański (PhD), Prof. J. Łęski, *Fuzzy clustering with ε-hyperballs and its application to data classification*

The goal of clustering methods is to find groups (clusters) of similar objects in a given dataset, each group is represented by a prototype. Among various clustering methods,

procedures based on the minimization of the criterion function can be distinguished. In the case of fuzzy clustering, one object may belong to several clusters, with the membership degree value in the range [0, 1]. In the presented work a Fuzzy Clustering with ε-Hyperballs (FCεH) was proposed. In classical approach to clustering, prototypes are defined as points in a multi-dimensional feature space. In FCεH the prototypes are defined as hyperballs with a radius of ε, and the distances of objects located inside a hyperball from its center are considered as equal to 0. The FCεH criterion function is minimized using two Picard algorithms. The value of ε was set arbitrarily, as well as automatically, using the results of fuzzy c-means clustering. The proposed clustering was applied to determine the Gaussian membership functions in rule antecedents of the fuzzy classifier. The consequents of the rules were found using the iteratively reweighted least squares error minimization procedure with the conjugate gradient approach. The FCεH effectiveness was evaluated by the obtained classification quality. Six benchmark datasets related to various classification problems and represented by 100 divisions into training and testing sets were applied. The results were compared with three reference methods: Lagrangian SVM (LSVM) and the same fuzzy classifier, but with the antecedents determined using fuzzy c-means (FCM) and fuzzy (c+p)-means (FCPM) clustering. All clustering-based classification methods provided higher classification accuracy than LSVM. For all datasets FCεH provided lower classification error than FCM. Comparing FCεH with FCPM, only for two datasets the higher classification accuracy was obtained applying the FCPM.

M. Kotas (PhD, DSc), T. Moroń (PhD), M. Piela (MSc*), Spatio-temporal extension of independent component analysis for fetal ECG extraction*

Analysis of fetal electrocardiogram (fECG) has been the subject of numerous researches in recent years. Its attractiveness results from the non-invasiveness of the examination, which does not affect the mother and the fetus, and also from its relatively low costs. Research on this topic centers around overcoming the challenges and problems associated with fECG analysis based on maternal abdominal signals. Among the most important challenges, we can distinguish rather low energy of the fECG, in comparison to noise sources like maternal ECG or bioelectric activity of muscles. Many methods and algorithms have been developed, which aim at the improvement of fECG signal quality and its extraction from maternal abdominal signals. Effective decomposition of multichannel biomedical signals can often be achieved using the method of independent component analysis. This method performs separation of individual source signals using the conditions of their statistical independence and exploiting the model of blind source separation. However, one of the restrictions imposed by this model concerns the number of the source signals that can be separated. This number cannot be greater than the number of the measured signals (signal channels). Moreover, the algorithm applied to the signals with a low number of channels can be insufficient. Our experiments showed that recording only 4 channel abdominal signals does not always assure successful separation of the fECG. The proposed method is an extension of independent component analysis when applied for fECG extraction. Before using the classical

Independent Component Analysis method (ICA), we multiply the number of measured signals using the technique of delays. After this duplication of the measured signal channels, the classical Joint Approximate Diagonalization of Eigenmatrices algorithm (JADE) is applied to perform blind separation of independent source signals. Then we use a simple algorithm to select the estimated source signal that contains the fECG of the best quality. We compare the results obtained using the classical ICA and the approach proposed. The experiments performed on 4-channel maternal abdominal ECG signals confirm the superior performance of this approach. For most test signals investigated, this approach led to significant improvement of the fECG quality. It seems also possible to apply this approach to extend further the spatio-temporal ICA (STICA) capabilities. The method can be combined with the methods of projective filtering or various methods performing signals in the time domain. Such combinations can be applied also to accomplish a very demanding task of ECG signals decomposition during twin pregnancies.

E. Straszecka (PhD, DSc), S. Porębski (MSc), *Extracting easily interpreted diagnostic rules*

Rapid progress in medical sciences involves frequent modifications of medical procedures, which impedes diagnosticians' work. Thus, a support is inevitable for the proper diagnosis and treatment. However, diagnosis support systems are often disregarded because of high costs, complicated inference and inability to modify their knowledge bases. Due to the critical importance of a medical decision, a medical diagnosis support tool should not be intended to substitute a diagnostician. Hence, a knowledge base must be verified at all times and controlled by human experts both in the construction process and while being used by a physician. The aim of this work is to propose a method that helps to resolve these problems by extracting diagnostic rules that can be easily interpreted and verified by experts. The proposed diagnosis support allows physicians to use their own data to represent an imprecision of symptoms by means of fuzzy sets and an uncertainty of diagnosis by a basic probability assignment, defined in the Dempster-Shafer theory. Data-driven knowledge, extracted in this way, is next examined for the significance of its rules to select the best rules. Different rule evaluation methods are proposed that prevent some of the imperfections of the existing methods. Next, intuitively clear reasoning is suggested to elaborate on the diagnosis. Moreover, a new rule selection algorithm is proposed. A generalization quality of the extracted rules is examined. Particular attention is paid to the evaluation of the extracted rule set according to its reliability and clarity for a human user. Experimental results obtained for popular medical data sets demonstrate advantages of the proposed approach. For each data set, simple and readable rule sets are determined.

GROUP FOR MICROELECTRONICS AND NANOTECHNOLOGY

W. Filipowski (PhD), E. Wróbel (PhD), K. Drabczyk (PhD), K. Waczyński (PhD, DSc), G. Kulesza-Matlak (PhD), Marek Lipiński (PhD, DSc), *Spray-on glass solutions for fabrication silicon solar cell emitter layer*

About 90% of solar cells manufactured in the last years were based on crystalline silicon. At the same time the continuous reduction in production costs makes the low cost technology still interesting. The aim of this study was to investigate the possibility of homogeneous emitter layer production from the spray-on glass solution with resulting surface resistance in the range of 65-80 ohm/sq. Due to the solution applying method the key parameter is the viscosity of the solution, therefore, viscosity measurement of prepared dopant spray-on glass has been made.
In this research the preparation and application procedure of doping glass deposition were investigated. The viscosity and density of glazes were measured at weekly intervals to check their suitability for spray-on technology.
The glass liquid was deposited on the silicon wafers surface by a spray-on method using the airbrush powered by compressed nitrogen. The applied glass layer was dried by increasing the temperature in the range from 20°C to 255°C in 2 hours. The plate was transferred directly from the drier to a resistance furnace with one side open quartz tube, where the dopping process was carried out in nitrogen atmosphere. After the diffusion process the PSG layer was removed in hydrofluoric acid (HF) bath.
The resulting doping solution was used to form an emitter layer on the textured substrate. The main parameters of the prepared doped layer: distribution of sheet resistance and relationship between the sheet resistance Rs and the time of diffusion process have been presented. Distribution of sheet resistance was measured using the four-pin probe ResTest 2101. Sheet resistance of the emitter layer obtained using the prepared doping solution has parameters which do not differ from the layer obtained with the use of commercial spin-on dopant glasses. With the passage of time, an increase in the viscosity of the solution, which has a significant impact on the possibility of spray-on application method, has been observed.

P. Kowalik (PhD), *The usage of layers based on Ni-P alloy in the film resistors technology and photovoltaics*

This project was aimed at the development of a technology of amorphous materials based on *Ni-P* alloy and its application in the electronics, particularly in precise thin film resistors and photovoltaic cells. The summary of the work concerning the amorphous layers based on *Ni-P* alloy performed by the author at the Institute of Electronics was presented in a monograph with the title given in the heading.
The author presents production of resistive layers that enable to obtain surface resistance in the range of (0,2÷100) Ω/□. In the work results of the research were presented, performed on *Ni-P* layer and *Ni-P* layers enriched with copper (*Ni-Cu-P*),tungsten (*Ni-W-P*) and cobalt (*Ni-Co-P, Co-P*). The influence of additional *Ni-Cr* substrate layer on

electrical parameters of a newly created (*Ni-Cr+Ni-P*) resistor, was analyzed as well. Particularly, the analysis of structural changes in amorphous alloy during thermal stabilization and their influence on the resistor's basic electrical parameters and evaluation of temperature range that enables to obtain resistors' parameters corresponding to precise layered resistors was performed. An attempt to find the correlation between parameters of the layers production and electrical parameters of the final product was made. As a result, a computer program has been created that defines parameters of the technological process that produces resistors based on the user's value input.

The latest trends of layers based on amorphous *Ni-P* alloy usage in the production of the electrode in the structure of photovoltaic cells were also discussed. Obtaining high conductivity and precise contact layers in the low-cost process are one of the main issues in photovoltaic technology. The author proposed the method of photovoltaic structure selective metallization with *Ni-P* and *Ni-Cu-P* alloy. The electrodes created in this manner have parameters closely related with electrodes produced during the screen printing method. The advantage of the developed technology is simplicity of its application and lower electrodes manufacturing cost in comparison with thick-film technology.