

Centre of **Sensor, **I**nformation and **C**ommunication **S**ystems (**SIX**)**

Research and Development Offer of Services

**Brno University of Technology
Faculty of Electrical Engineering and Communication**

Brno, 2011

Centre of Sensor, Information and Communication Systems (SIX)



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1 Introduction

The SIX Centre was established by the Department of Physics, the Department of Microelectronics, the Department of Radio Electronics, and the Department of Telecommunications, Faculty of Electrical Engineering and Communication, Brno University of Technology. The laboratories of the SIX Centre were developed from the existing research infrastructure, which was significantly updated thanks to an investment in the amount of EUR 10 000 000.- from the CZ.1.05/2.1.00/03.0072 project of the operational programme *Research and Development for Innovation*.

Activities of the SIX Centre are focused on the research into and development of communication systems in some much promising frequency bands. Attention is turned to hardware solutions of systems, to communication and control protocols, to the security of the transmission of information, and to the corresponding network technologies. We also investigate techniques that enable reproducing the transmitted information with high fidelity and high resolution. The interactivity of the user/device interface is becoming more and more important.

Research of the SIX Centre is divided into five programmes:

- Microwave technologies;
- Wireless technologies;
- Converged systems;
- Multimedia systems;
- Sensor systems.

In the following chapters, the research and development services of the programmes of the SIX Centre are offered. The research and development results obtained so far are illustrated by examples of newly finished or running projects and research contracts.

Thanks to the strong connection between the research centre and the university, SIX can also provide consulting services, prepare special lectures for employees of companies, and find and educate new promising employees. The SIX Centre is highly interested in joint research projects with partner companies within the frame of the Technology Agency of the Czech Republic, research programmes of Czech Ministries, and European research programmes.

Further information about the SIX Centre is available on the web page

<http://www.six.feec.vutbr.cz> .

The sixth sense for communication systems of the future is the motto of the SIX Centre. We invite partners to work with us on this vision.

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2 Programme of Microwave Technologies

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The research program deals with the solution of physical problems of the propagation of electromagnetic waves in the frequency bands of (sub)millimetre waves, conducts research into antennas and circuits that are needed for the processing of high-frequency signals. Investigating the biological effects of the operation of wireless communications and exploiting the knowledge of electromagnetic field properties in biomedical applications are also a part of the research.

The programme offers research and development services in the following areas:

Numerical modelling

- Numerical modelling of microwave antennas, circuits and components of a wireless communication system, using commercial programs (ANSOFT, COMSOL, CST) and in-house programs (method of integral equations, finite-element method)
- Development of numerical models and methods for virtual certification of various objects (small airplanes, electrically driven cars, etc.) from the viewpoint of electromagnetic compatibility (EMC)

Optimization

- Optimization of antennas, filters and circuits by conventional methods and original multi-objective global optimization approaches
- Exploitation of artificial intelligence (artificial neural networks) for the solution of the electromagnetic compatibility (EMC) of the devices developed

Antenna

- Development of planar, wire and semiconductor antennas
- Development of antennas for automotive applications, radio-frequency identification (RFID) systems and special communication services
- Development of special antennas for frequency bands of 60 GHz, 71 to 76 GHz, 81 to 86 GHz, and 92 to 95 GHz

Passive and active microwave circuits

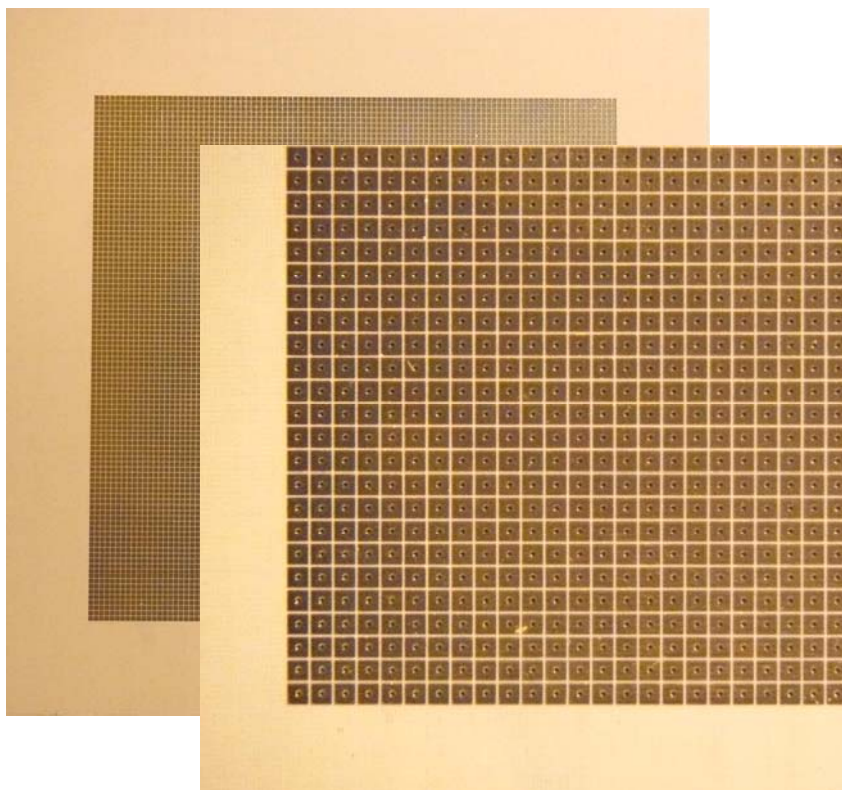
- Development of microwave filters, amplifiers, couplers and other components
- Development of special periodic structures with electromagnetic band gap, artificial magnetic conductors, and meta-material structures
- Development of microwave structures based on substrate integrated waveguides
- Development of special power microwave filters
- Development of applications for satellite systems

Measurement

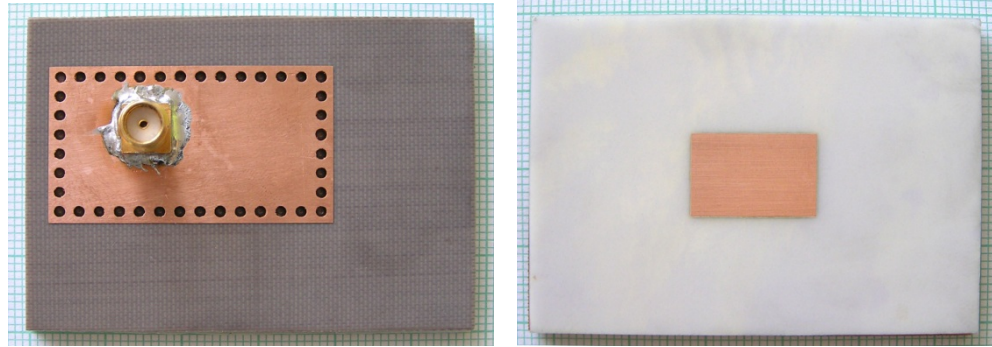
- Measurement of antennas and circuits up to 110 GHz
- Pre-compliance EMC testing
- Near-field phaseless antenna measurements



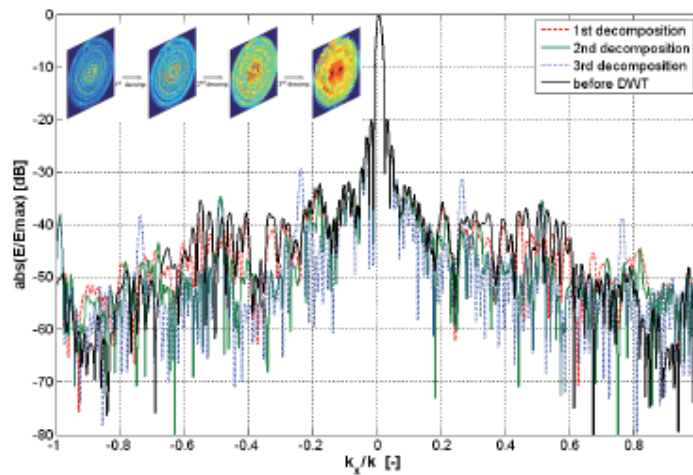
Semiconductor transmission lines with distributed amplification. Transmission lines are developed for millimetre-wave applications. The research was financed by the grant of the Czech Science Foundation no. 102/07/0688 *Advanced microwave structures on non-conventional substrates*.



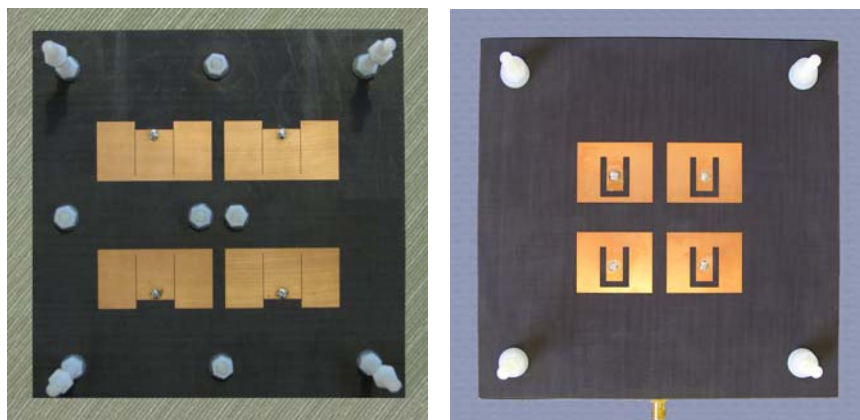
Mushroom periodic structure behaving like an artificial magnetic conductor (AMC). AMC can be used as reflectors of low-profile microwave antennas. The research was financed by the grant of the Czech Science Foundation no. 102/07/0688 *Advanced microwave structures on non-conventional substrates*.



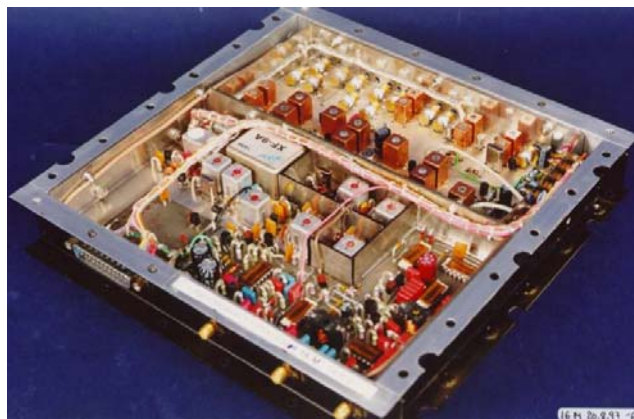
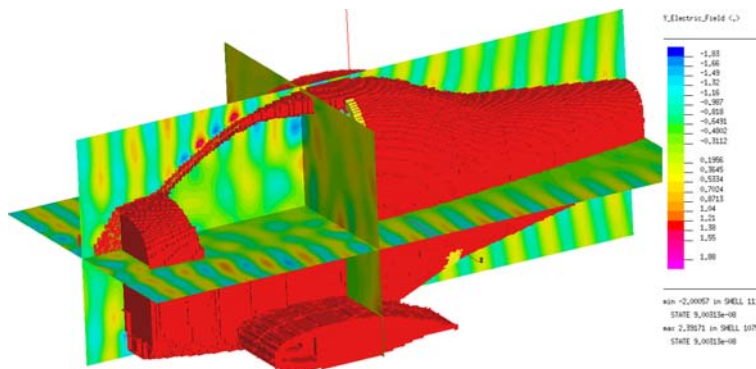
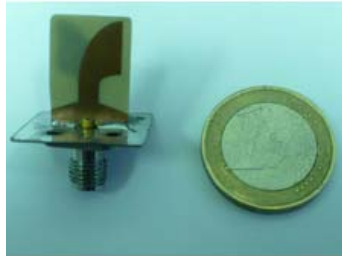
Microstrip patch antenna fed by substrate integrated waveguide (SIW). The SIW technology combines advantages of waveguides and planar circuits. The research into SIW is a part of the European project COST IC0803 RF / *Microwave communication subsystems for emerging wireless technologies*.



Near-field phaseless measurement of radiation patterns of antennas. The problematic measurement of phases at higher frequencies is substituted by amplitude measurement only. Computational requirements of the measurement were reduced by the exploitation of the discrete wavelet transform. Near-field phaseless measurement is being developed in cooperation with the University of Calabria (Italy).



Planar antenna arrays with improved bandwidth. Wideband planar antenna arrays are being developed in cooperation with Tesla Holding within the frame of the Czech Ministry of Industry and Trade project no. FR-TI2/039 *A set of antennas*.



Selected research and development projects

High Intensity Radiated Field – Synthetic Environment

Project FP7 no. 205294, domain Aeronautics and Transportation

Duration: from December 1, 2008 to November 30, 2012

<http://www.hirf-se.eu>

A consortium consisting of 44 aircraft producers, software developers, universities and research institutes is engaged in the project. Attention is turned to the development of a software framework that enables designers to consider the immunity of an airplane against external electromagnetic fields and interference during the design process. We are contributing by the development of two software modules – the time-domain finite-element solver and artificial neural networks for the modelling and classification of electromagnetic phenomena.

Antennas for Car2Car Communication

Research contract for Volkswagen AG

Duration: from July 1, 2008 to December 31, 2010

The project was focused on the research into antenna systems for cars. Antenna systems had to enable reception of phone signals, navigation GPS signals, satellite DSRC radio, and had to enable car-to-car communication. The influence of the curvature of the roof, roof windows and other objects on the car roof had to be carefully investigated.

Evaluation of Finite-Element Software

Research contract for EGSTON GmbH

Duration: from May 1, 2011 to August 31, 2011

In the frame of the contract, the properties of the commercial COMSOL Multiphysics software were tested in detail. The suitability of the software for the development of multi-physical models of power electromagnetic devices was evaluated. Attention was turned to the co-simulation of the electromagnetic part of the device and the electronic circuitry part.

A Set of Antennas

Project of the Ministry of Industry and Trade no. FR-TI2/039

Duration: from January 1, 2010 to December 31, 2012

Attention is turned to the development of four antenna systems: (1) a flat panel antenna for tactical communication systems (high-capacity microwave link supporting standard operations in the direct line of sight), (2) a vertically polarized high-power panel antenna for the DVB-H and DVB-T terrestrial digital TV transmission; (3) a compact vertically polarized multi-storeyed antenna system for the DVB-H and DVB-T terrestrial digital TV transmission, and (4) flat panel antennas for the 14.2 to 15.5 GHz and 26.5 to 27.5 GHz frequency bands.

New Technologies for Microwave Links

Project of the Ministry of Industry and Trade no. FR-TI3/447

Duration: from January 1, 2011 to December 31, 2013

The project deals with the development of a complete series of radio relay links operating in the 4.4 to 5.0 GHz, 38 GHz and 75/85 GHz frequency bands. In the prototypes of radio relay links operating at 4.4 to 5.0 GHz and at 38 GHz, novel technologies increasing the capacity and the optimality of operation will be implemented. The implemented technologies comprise an automatic selection of modulation, bandwidth switching, suppression of interference caused by cross-correlation, and beam-width switching of antennas. Research into and development of microwave links operating at 75/85 GHz should result in a new series of circuits of the microwave link in order to define its new architecture considering results of simulations and measurements on an experimental link.

Analytic Research into Threats in Electromagnetically Integrated Systems

Project of the Ministry of Industry and Trade no. FR-TA4/043

Duration: from January 1, 2007 to May 6, 2010

The project was aimed at creating and verifying novel analytical and experimental methods for verifying the inherent protection of small airplanes and devices installed in them against electromagnetic influences of the external environment. The verification was to cover all the design phases, starting with the virtual prototype of an airplane and finishing with the flight test, including certification. Such methods enable a sophisticated design of airplanes respecting their operation in expected conditions of the external electromagnetic environment, which includes indirect effects of lightning and strong electromagnetic fields radiated by transmitters and radars. An airplane design that considers the above environmental threats positively influences the safety of air traffic and increases the utility value of the airplane.

Advanced Microwave Structures on Non-conventional Substrates

Project of the Czech Science Foundation no. 102/07/0688

Duration: from January 1, 2007 to December 31, 2011

The project was focused on the development of novel numerical models of planar microwave structures on non-conventional substrates (meta-materials, semiconductor substrates), on the research into novel approaches to composing multi-criterial functions in the frequency domain and the time domain, on the development of original modifications of global evolutionary algorithms and swarm-intelligence algorithms for searching for the Pareto sets of optimal solutions. Numerical models were based on inherent wave equations (Maxwell equations), particle equations (Schrödinger equations) and their multi-physical solutions. Models reflected the periodic structure of meta-materials, the structure of semiconductor materials and their mutual combination. When composing multi-objective functions, mutual combinations of micro- and macroscopic parameters from the viewpoints of space, time, and frequency were considered. In order to minimize objective functions, hybrid global optimization methods were developed via combining and modifying existing global algorithms and completing them with local algorithms.

Millimetre-wave Electromagnetic Structures for Biomedical Research

Project of the Czech Science Foundation no. P102/12/1274

Duration: from January 1, 2012 to December 31, 2016

Technological development in the area of novel electromagnetic systems operating in higher frequency bands opens up questions related to the influence of electromagnetic fields on biological tissues. Existing studies show that waves in the emerging frequency bands can cause not only the heating of the tissue but can also initiate changes in the cell structure. The project is aimed to provide the necessary tools for research teams which are active in the area of biomedical research. The project deals with three topics: (1) research into implantable antennas and antennas operating in the vicinity of biological tissue, (2) research into microwave imaging based on multi-objective optimization techniques, and (3) research into artificial neural networks for the suppression of noise in the measurement.

Novel Methods of Multi-objective Synthesis of Antennas on Special Substrates

Project COST OC08027

Duration: from January 1, 2008 to May 31, 2011

The project was aimed at working out a methodology of complex synthesis of antennas on periodic substrates, which were going to be used in emerging communication services and special applications.

Components of Advanced Radio Communication Systems

Project COST OC09016

Duration: from January 1, 2009 to June 17, 2012

The project is aimed at working out an interdisciplinary methodology of the design of emerging communication systems (a complex understanding of the design of the whole system, a complex approach to the design of partial electronic circuits, software equipment and systemic connection of all components).

3 Programme of Wireless Technologies

Prof. Stanislav Hanus, hanus@feec.vutbr.cz

The program follows up on the basics established in the programme of micro-wave technologies. The programme examines systemic problems of wireless communication, addresses problems of protocols, and relations to information systems. The programme investigates novel circuitry for the processing of signals in the intermediate frequency band.

The programme offers research and development services in the following areas:

Wireless optical communication

- Testing of qualitative parameters of links and recommendations for the installation in the area of optical or hybrid wireless communications
- Evaluation of statistical parameters of the atmosphere for a selected locality and determination of the availability of a given channel positioned in the chosen locality
- Measuring the power and spectral characteristics of optical sources and optical receivers in the 850 nm, 1300 nm and 1550 nm bands
- Measuring the parameters of optical fibres and the distribution of optical intensity at the optical fibre output
- Measuring the bit error ratio in the baseband up to a rate of 11 Gb/s

Wireless mobile networks

- Measuring the quality of mobile networks of various operators
- Analysis of problematic network spots
- Measuring the interference between mobile networks and the DVB-T network
- Measuring the throughput of networks

Digital radio and TV broadcasting

- Measurement and analysis of transmission in the DVB-S/C/T/H/SH/S2/C2/T2 /IPTV/3DTV standards
- Digital radio broadcasting and multimedia in the DAB/DAB+/DMB standards
- Mobile and satellite DVB-H/SH digital TV
- Availability and quality of the picture, sound and DVB/DAB/DMB services
- Measuring the signal coverage and interference in DVB/DAB/DMB broadcast networks
- Monitoring and optimization of SFN broadcast networks for DVB/DAB/DMB
- Methodology of measuring and testing DVB/DAB/DMB receivers

- Measuring the broadcast of hierarchically modulated digital TV in the DVB-T terrestrial broadcasting and in the DVB-H mobile network
- Testing the tuners of DVB-T receivers in the automotive technology
- Simulation of the broadcasting and the transmission distortions in the DVB-T digital TV
- Evaluation of the quality of a compressed picture for various bit rates
- Measuring the parameters of receivers and set-top boxes for the DVB-T digital TV

Radio-communication systems

- Solution of microwave radio relay channels for high-speed data communication
- Development and realization of modems for remote communication with sensors in the HART protocol with the BELL 202 standard
- Development and realization of radio modems for telemetry transmission with the DMB protocol
- Testing of systems for UWB communication and vehicle localization
- Measurement, modelling and design of radio communication systems
- Designing algorithms for the detection of spectrum utilization
- Designing frequency synthesizers for the transmitters on the PLL principle with a fractional division ratio
- Two-dimensional signal spreading in systems with several carriers, and the estimate of channel parameters
- Reduction of the PAPR ratio for OFDM systems with a low computing demand factor
- Adaptive modulation with an effective FEC coding on the basis of turbo codes

Simulation and modelling of electronic circuits

- Modelling of mixed systems in the VHDL-AMS language
- Analysis of parasitic effects in nonlinear dynamical systems (chaos)
- Designing multifunctional electronic filters and oscillators

High-speed communication systems

- Analysis of interconnects and high-frequency circuits up to 20 GHz, with the time-domain analysis also possible
- Analysis and optimization of high-speed serial links (design and testing of high-speed transmission systems up to a bit rate of 16 Gb/s)
- Testing of devices for the USB 3.0, HDMI, SATA, and other communication standards.
- Analysis and computer modelling of multi-conductor transmission structures

Design and implementation of special devices

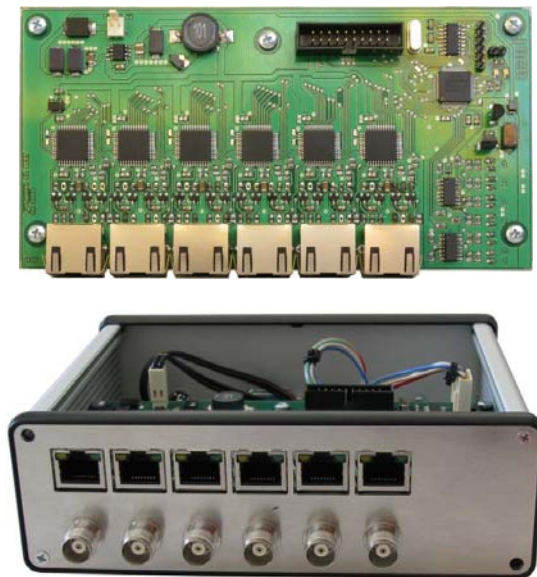
- Design of apparatus concepts, schematics, printed circuit boards, providing for the manufacture (PCB, mounting), designing and building a mechanical construction, testing (functionality, parameters, EMC)
- Power supplies; design (circuitry, PCB), launching and testing
- Application of FPGA circuits; development, implementation and launching of FPGA systems, a complete design of FPGA configurations

Application of multi-processor systems

- Implementation of algorithms into microprocessor platforms
- Development of algorithms for multi-core architectures
- Optimization of source codes with a view to computation severity and memory demands
- Design and optimization of communication protocols with a view to the bit rate, reliability and consumption
- Cognitive access to the transmission medium

Design techniques

- Development of printed circuit boards (Eagle, Altium Designer)
- Design of FPGA circuit configuration (Xilinx, Altera, VHDL, Verilog)
- Atmel AVR, ARM, and x51 architectures in the microprocessor area

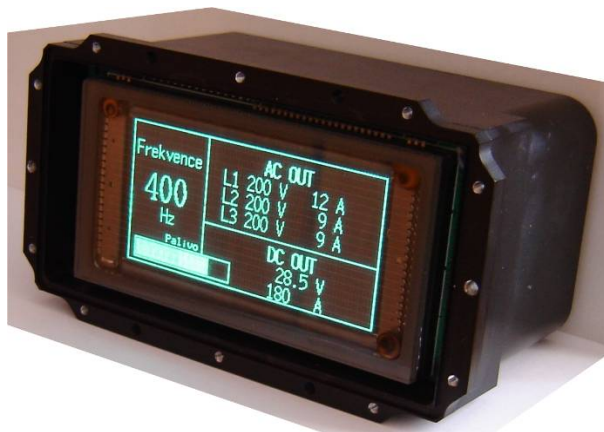


Six-channel error rate meter E1: Six-channel error rate meter (transmitter and receiver) for serial links with a bit rate of 2.048 Mb/s (standard E1, ITU-T G.703), with RSSI measurement (Received Signal Strength Indication). Electrical interface with RJ-45 connectors; developed for the Testcom (Prague) company. Processor: LPC2136, NXP Semiconductors (Philips). Data transfer from BERT integrated circuits into the PC via UART, tester controlled from the PC via a terminal utility, and sampling of RSSI signals (8-bit, 1 kbps).

<http://www.urel.feec.vutbr.cz/~kubicek/manual-6xE1-2008.pdf>



Nine-channel digitizer: Sampling 9 x 122.88 MHz @ 16b, 9 x antialiasing filter, 2 x data transmission net interface (1000BASE-xx), remote control, and 12-layer PCB reconfiguration.



Multifunctional display for a ground-based helicopter generator: Measuring the parameters of the 28V_{DC} and 200V_{400Hz} output voltages, provision of protection functions, realized on the ARM platform.



Control units for the 28V_{DC} and 200V_{400Hz} generators: generator control, provision of protection functions, communication with the master system via the CAN bus, realized on the ARM platform.

Selected research and development projects

Agile RF Transceivers and Front-ends for Future Smart Multi-standard Communications Applications (ARTEMOS)

Project ENIAC Joint Undertaking no. 270683-2

Duration: from April 1, 2011 to March 31, 2014

<http://www.artemos.eu/>

The ARTEMOS international project is targeted at the research into and development of the architecture of a new generation of mobile receivers and the application of the new technologies of embedded agile and cognitive radio. The novel receiver architecture enables multi-standard, multi-data and multi-signal functioning, with a fast reconfiguration capability. The agile receiver will embody a high degree of modularity and integration of individual building blocks under simultaneous low power consumption and operating costs. The Department of Radio Electronics FEEC BUT in Brno cooperates on the project with the TESLA, a.s., company and is a part of the consortium of further 36 international and transnational companies and universities. We participate in the solution of working packages WP1 - System architecture and control, WP3 - Solution of input receiver tunability, WP4 - Modem function, and WP5 - Methodologies and simulations. The project is coordinated by the DMCE GmbH & Co KG Company, resident in Linz, Austria.

Research into and Modelling of Advanced Methods of Image Quality Evaluation (DEIMOS)

Project of the Czech Science Foundation no. GAP102/10/1320

Duration: from January 1, 2010 to December 31, 2014

<http://www.deimos-project.cz/>

The project is targeted at the research into and modelling of image quality assessment in technical image systems where a human observer is the ultimate evaluator. The aim is to prepare models and means suitable for perceptual optimization of these systems. The project content includes creating a database of typical image distortions in systems for sensing, transmission, reproduction, recording and processing of image information. Attention is also paid to the analysis and modelling of the impacts of current and emerging video coding and transmission tools on the subjective image/video quality, with emphasis on QoE (Quality of Experience). The project is solved together with the Dept. of Radio Electronics FEE CTU in Prague and follows up on the activities of the COST IC1003 action *European Network on Quality of Experience in Multimedia Systems and Services (QUALINET)*.

Analysis and Simulation of the Transmission Distortions of the DVB-T/H Digital Television

Project of the Czech Science Foundation no. 102/08/P295

Duration: from January 1, 2008 to December 31, 2010

The project dealt with the research into transmission distortion problems in the digital television transmission according to the DVB-T/H standard in the RF band, and with the creation of complex computer models of individual distortions.

Digital television transmission according to the DVB-T standard is generally characterized by that a constant picture quality is secured even if the receiving conditions get worse. However, transmission distortions have a significant influence on transmission error rates; but thanks to error-protected transmission a damaged MPEG-2 TS data stream can to a certain extent be decoded and corrected. It has been found that significant influence on the transmission distortions is exercised not only by the channel encoder and modulator parameters, but above all by the very transmission channel in the RF band and its model.

Study of Optical Beams for Atmospheric Static and Mobile Communications

Project of the Czech Science Foundation no. 102/09/0550

Duration: from January 1, 2009 to December 31, 2011

The project dealt with the basic research into new types of optical sources and the properties of their optical beams applicable to optical wireless communication. It focused on both the problems of external and internal optical networks. The project solved various possibilities of the implementation of elements (EDFA, WDM and ADM), and fibre optics approach with regard to the technology of wireless connections. Based on the light-and-atmospheric-interaction model, modulation techniques were designed and communication limits defined that concerned the bit rate, reliability and bit error rate of the links, with the optical mobility of stations maintained.

Contactless Optical Measuring Techniques and Systems for Precision Engineering

Project of the Ministry of Industry and Trade no. FR-T12/705

Duration: from January 1, 2010 to December 31, 2014

This project of applied research is focused on research in the field of precision contactless measurement in precision engineering, and on subsequent know-how transfer of the participating research units into innovative and competitive industrial products and technologies. The principal contributor of private resources into this project is the firm Mesing, s.r.o., which acts within the framework of the project as partner no. 1, and which is at the same time the main industrial user of the project results.

Testing 3G Mobile Networks in Selected Cities of the Czech Republic

Research contract for T-Mobile Czech Republic

Duration: from February 2, 2011 to February 28, 2011

At the Dept. of Radio Electronics FEEC BUT in Brno, a measuring technology was developed which was used by measuring teams to test 3G mobile networks in selected cities of the Czech Republic, as specified by the project submitter. The data measured were statistically processed and selected parameters of the mobile networks measured were mutually compared. To assess the rate of individual 3G mobile networks the following parameters were selected: downlink bit rate in kbit/s, uplink bit rate in kbit/s, network time response in ms, and web page download bit rate in kbit/s. The server connected to the BUT network was utilized for the meas-

urement. The server used is connected via 1 Gbit/s Ethernet into the CESNET academic network, and has a fixed public IP address. Using the described connection configuration, any influence on the measured results on the part of the server part was eliminated.

4 Programme of Converged Systems

Prof. Kamil Vrba, vrba@feec.vutbr.cz

The programme concentrates on the convergence of the telecommunication systems and the information systems in a whole spectrum of problems. The research is closely connected to the research outputs of the programme of wireless technologies; outputs of the programme of converged systems are here converted and processed by highly sophisticated methods.

The programme develops devices and protocols for a quick and secure hyper-media data transmission, researches data processing and archiving methods, and proposes novel services. The programme implements outputs of the research of the programme of multimedia systems into converged systems; attention is turned to speech processing techniques and image processing methods.

The programme deals with research into telecommunication circuitry for signal processing at intermediate frequencies, and with the processing of mixed signals.

Within the frame of this programme we offer research and development services in the following areas:

Network technologies and applications

- Evaluation of the behaviour of new algorithms and protocols for data networks, using the OPNET Modeler simulation environment. Monitoring and analyzing the data network traffic.
- Design of optical networks, utilization of optical networks in industrial applications, measurement and monitoring of optical networks.
- Exclusive technological background offered to commercial subjects as from the 3rd quarter of 2012.
 - The first experimental backbone network infrastructure based on 10GbE technology which is free for rent in the Czech Republic.
 - The first experimental distribution network free for rent in the Czech Republic. It is made up of more than 30 highly efficient routers with the support for IPv6, MPLS, VPN, the latest methods of QoS, multicasting, xDSL technologies, routing outside of and also between autonomous systems, etc.
 - The first experimental Storage Area Network (SAN) which is free for rent in the Czech Republic.
 - The largest leasable set of physical and virtual experimental stations for testing new network applications in the Czech Republic.
- Expert services offered to commercial subjects as from the 3rd quarter of 2012:
 - In accordance with customers' needs we can build large heterogeneous testing networks in our laboratories.

- We offer customers minute testing and analysis of newly developed network services in laboratory conditions, using networks which truly copy large commercial network infrastructures.
- In accordance with customers' requirements, we design and perform load and functional tests for newly developed network applications.
- Design of software and development of hardware-accelerated network elements which are built on FPGA and can work in the full duplex mode up to a bit rate of 10 Gbps, e.g. new algorithms for routing and switching in active network elements.
- Load testing of efficient backbone switches and routers up to 10 Gbps including long-term capture of the full duplex 10 Gbps data stream, its storage, analysis and a new subsequent transmission.
- Real-time filtering and analysis of the full duplex data stream up to 10 Gbps in IP networks. Development of custom-made systems for the detection of cyber-attacks on the network. Identification of specific data streams and their modification.
- Analysis of users' behaviour using an analysis of the IP network traffic.
- Analysis of communication in the WLAN network and GSM/UMTS mobile networks.
- Expert services offered to R&D institutions as from the 1st quarter of 2012:
 - We offer advanced modelling of network technologies and services to developers. We have the most skilled Czech university team in this specialized area, which uses the OPNET Modeler environment.
 - We offer the creation of simulation models to developers. These models are able to cooperate with real network elements.
 - According to the customer's needs, we provide an analytic description and subsequent models of network services and technologies requested.

IP telephony and multimedia applications

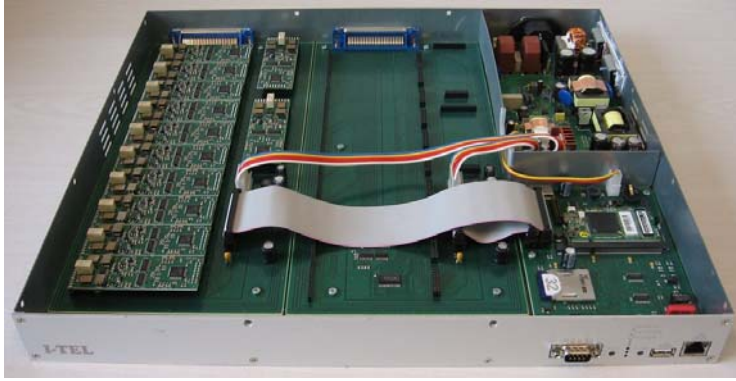
- Design and implementation of the hardware and software of subscriber terminals (telephones and others).
- Design and implementation of the hardware and software of telephone exchanges, soft-switches, VoIP and media gateways, special equipment of telephone exchanges in call centres, testers for the manufacture of telecommunication devices, implementation of load tests of telecommunication systems, design and implementation of telecommunication system protection, testing of the resistance of soft-switches to cyber-attacks.
- We offer custom development of network multimedia applications for various target platforms.

Communication, information and telemetric systems

- Solution of cryptographic security in data networks, communication and information systems. Security of data and electronic archives, access control solutions.
- Design and implementation of Authentication, Authorization and Accounting (AAA) systems, analysis and design of cryptographic protocols, design of anonymous authentication systems.
- Custom testing of ADSL and VDSL modems and DSL access multiplexers, testing of triple-play services.
- Testing of network security, efficiency and throughput for applications which communicate using layers L4 to L7. Testing based on databases of security threats (CVE, CCE, CPE, CVSS, XCCDF, OVAL...).
- Design of telemetric systems and systems for telerecording. Systems for Wireless Sensor Networks (WSN), design of sensor networks, data networks for telerecording and process control in industry (water supply, sewage treatment, heating, transport, etc.).
- Design of advanced and sophisticated telematic systems in transportation.
- Communication systems for crisis management of villages and towns, e.g. monitoring of harmful elements in the air, monitoring of high flood-water wave. Systems for agriculture, e.g. monitoring of soil retention, landslides.

Specialized instruments, devices and electronic circuits

- Development of unique electronic measurement instruments.
- Development of devices for medicine, transfer of data from medical devices, and data processing.
- Exclusive technological background for the development and manufacture of devices offered to commercial subjects as from the 3rd quarter of 2012:
 - Optical, X-ray and infrared analyses of printed circuit boards with mounted devices and of larger functional blocks. Detection of all common defects using manual, semiautomatic and fully automatic methods of processing object images.
 - Visualization of radiated electromagnetic and thermal fields of electronic circuits on printed boards – intensity and position measurement of the source of radiation, which is suitable for ensuring electromagnetic compatibility (EMC)
 - Testing of temperature and (common or even extreme) climatic effects on products, using the climatic chamber.
- Design, modelling, construction and measurement of analogue electronic circuits with emphasis on high frequencies, low noise and low consumption.
- Design of digitally controlled devices (signal sensors, stepper drives, converters).



Modular IP telephone exchange I-TEL with analogue line support. The I-TEL modular telephone exchange fills the gap between the analogue and the full digital (VoIP) telephony. It has the Ethernet interface at the input and 48 analogue telephone lines at the output. It supports all common VoIP protocols on the digital interface side. The number of output telephone lines could be chosen in the range from 2 to 48. This variability is enabled by the usage of two-line subscriber modules with integrated circuits of the Si32xx series. The telephone exchange is controlled by an ARM XScale microprocessor.



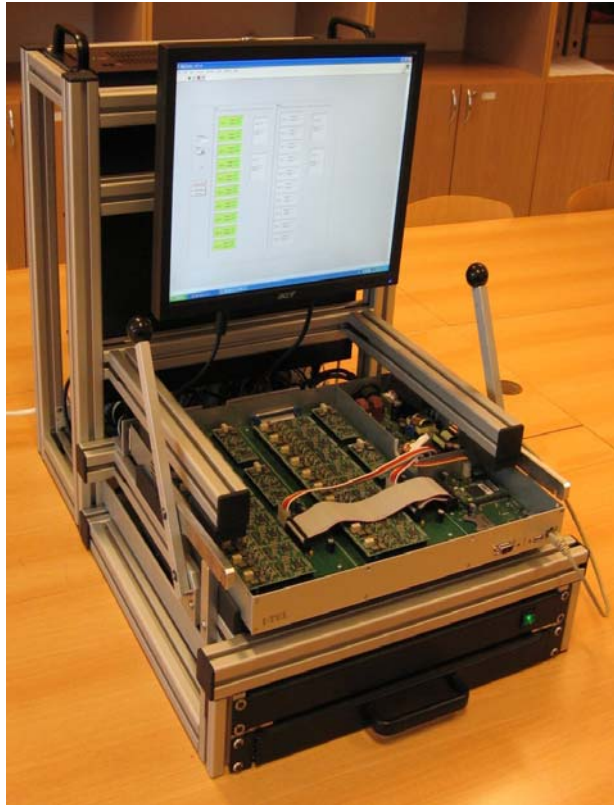
Application set of a 240-line modular IP telephony exchange. The application set combines 5 modular I-TEL telephone exchanges in order to increase the number of output telephone lines to 240. To ensure the interoperability of all 5 telephony exchanges, the DK1 set contains a small control PC and an Ethernet-switch for interconnection of data lines. The control PC also provides some extended functions of the telephone exchange such as remote management and diagnostics, recording the calls made, setting the user rights, and others.



Tester of telephone line modules based on the Silicon Labs Si32xxx circuits. The Si M01 tester is specially designed for the testing of subscriber line modules with integrated circuits of the Silicon Labs Si32xx series. The tester consists of the aluminium chassis, the box with electronics for testing, and the control industrial PC with a multifunction measurement card. The whole device is designed such that non-professionals can do these tests. The whole test and its result are displayed for the operator on an LCD screen.



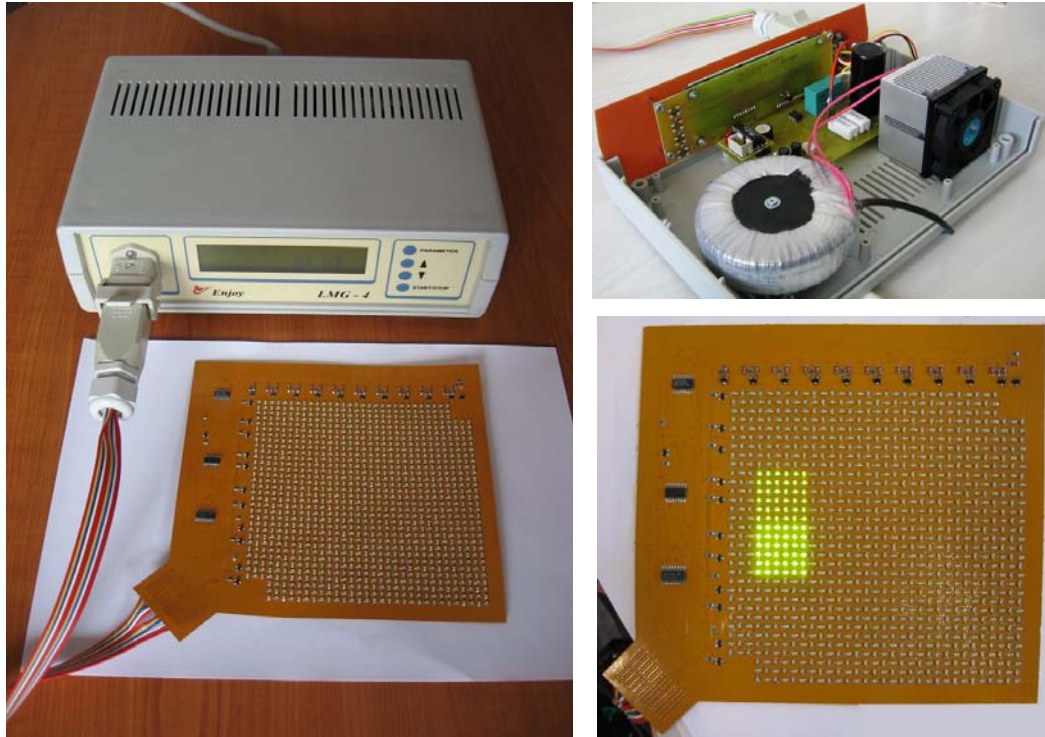
High-power current pulse generator H01 for induction coil excitation. The H01 generator is a single-output high-power digitally controlled source of current pulses designed for the excitation of big induction coils used in experimental magnetotherapy. It has a user-friendly interface with alphanumeric LCD, which enables easy changing of pulse parameters such as the amplitude, period and others. The generator can produce positive, negative and bipolar pulses with a peak-to-peak amplitude of up to ± 100 A and an edge steepness of $10 \text{ A}/\mu\text{s}$. The pulse frequency can be set in an interval from 1 to 1000 Hz.



Tester of IP telephone exchanges with analogue line support. The IP V01 automatic tester enables the testing of I-TEL exchanges with up to 48 telephone lines. For this purpose, it contains a 96-channel, a digitally controlled switching array which can connect each line to one of the two testing modems. The test results are displayed for the operator on an LCD screen. The tester is designed such that non-professionals can operate it.



Current pulse generator H02 with high steepness of edges. The H02 generator is a single-output high-power digitally controlled source of short current pulses designed for the excitation of big induction coils used in experimental magnetotherapy. Due to an internal galvanically separated voltage source of 600 V, the generator can produce sharp current pulses with an edge steepness of up to 100 A/ μ s. In the menu, it is possible to choose positive, negative or bipolar pip pulses with a peak-to-peak amplitude of up to ± 100 A and with a frequency of 1 to 1000 Hz.

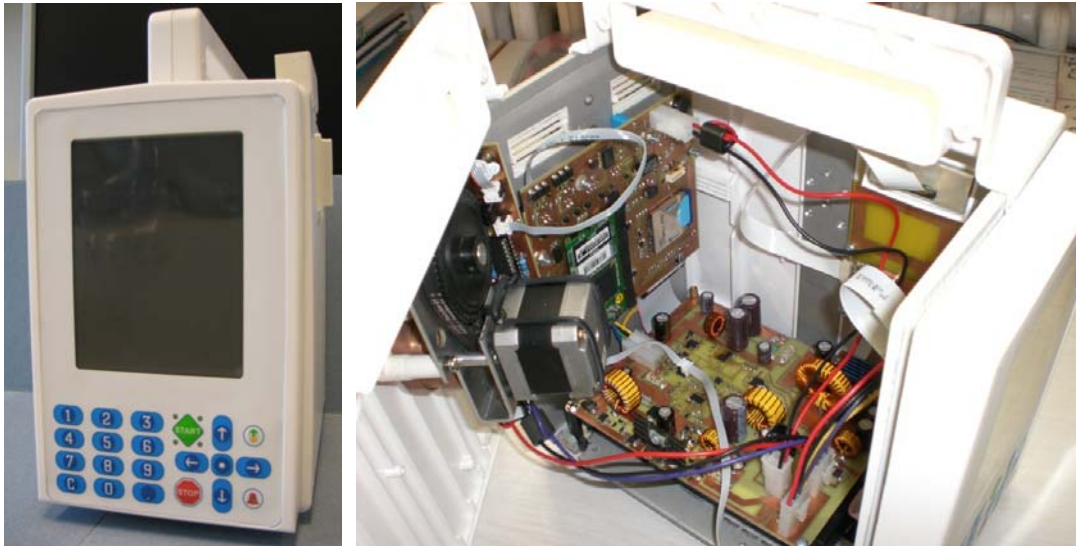


Generator of combined magnetic and optical pulses for skin application.

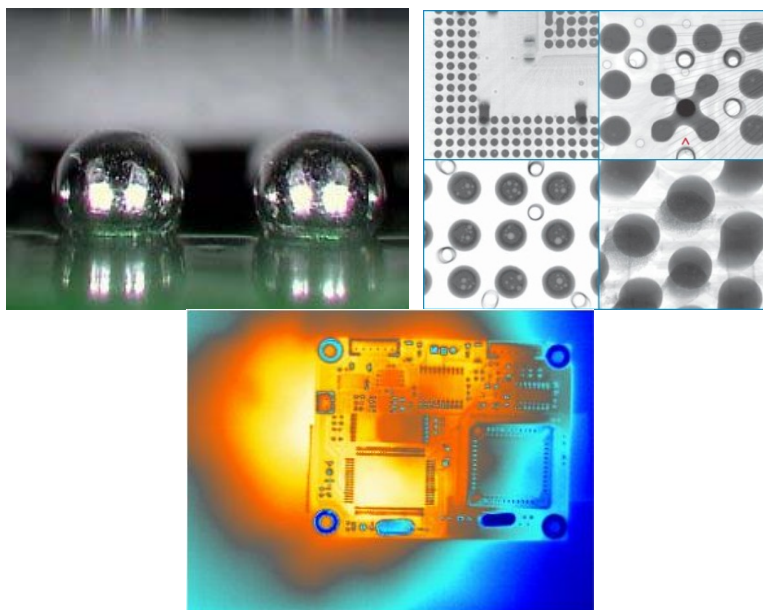
The LMG-4 generator is an experimental healing device for combined magnetic and optical skin therapy. The device produces a magnetic field which is thin but covers a large area. It uses a large number of little planar inductors placed on a flexible substrate. The set of inductors is supplemented with a dense matrix of bright-shining surface-mounted LEDs which provides light generation. Its advantages are the simple design and easy large-scale production. The intensity of the magnetic field generated is from 1 to 10 mT, the intensity of the luminous flux is from 0 to 800 cd/m², and the light wavelength is 550 nm.



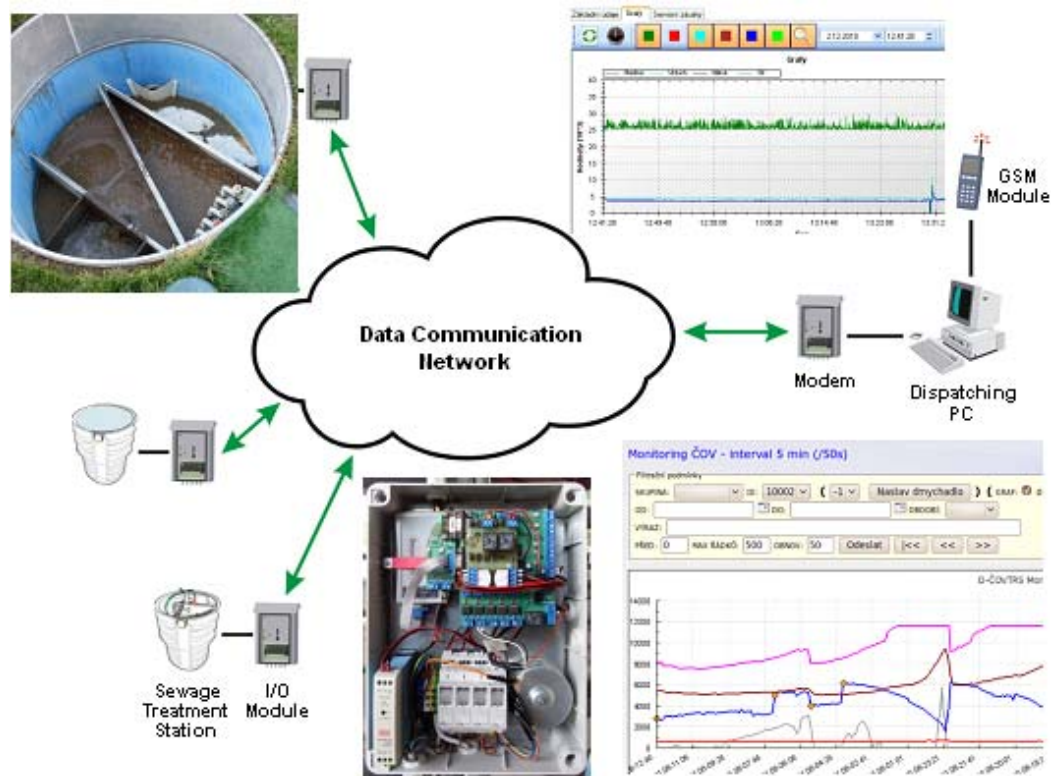
Multifunction system for alerting the population. The multifunction duplex-communication technology for alerting the population was developed in cooperation with the Satturn Company. The communication system uses original cryptographic authentication methods to protect it against unauthorized usage.



Development sample of the peristaltic infusion pump and a detail of its electronics. Development sample of the peristaltic infusion pump with connectivity to a hospital information system and to a centralized database of pharmaceuticals and patients. The system enables an automatic preset of the infusion pump as specified in the hospital information system, using communication through the 10/100Base-TX Ethernet. The nonlinear step-motor control allows the pump to reach the required accuracy even in the case of small doses from 1 to 10 ml per hour. The maximum flow rate is 2000 ml per hour. Circuits for the monitoring of activities, sensor of drops, sensor of bubbles in the infusion set and sensors of pressures in the infusion set and at the output of the pump were developed too. The pump can be remotely monitored from the supervisory centre created, and it is also possible to innovate some of the charts (pharmaceuticals, patients, doctors, code list of infusions) in the integrated SQL database.



Optical, X-ray and infrared analyses of PCB with the devices mounted.



Telemetric control system for distributed effluent treatment. The telemetric control system is designed for the remote monitoring and control of home sewage treatment plants. Individual home plants are equipped with control modules and sensors for the monitoring of technological processes of sewage treatment and they are mutually connected through a communication network. Data about the operation of such plants can be made accessible via the supervisory software to any number of users on the Internet.

Selected research and development projects

Overlapped Filter Bank MultiTone Modulation

Project of the Czech Science Foundation no. 102/09/1846

Duration: from January 1, 2009 to December 31, 2011

The project was focused on the research into an overlapped Filter MultiTone modulation system which enables a better bandwidth utilization and the use of a lower order of filters.

Computer Automation of Methods for Linear Functional Block Synthesis and Research into New Active Elements

Project of the Czech Science Foundation no. 102/09/1681

Duration: from January 1, 2009 to December 31, 2013

The goal of this project is to create a concept of a computer program for automated searching for new linear functional blocks with known and new active elements.

Simultaneously, the research into and design of inner structures of new active elements are in progress. These elements are being developed for circuits which operate in the current- or the mixed-mode.

Research of Mechanisms for Improving Access to Higher Quality Services in New Generation Data Networks

Project of the Czech Science Foundation no. 102/09/1130

Duration: from January 1, 2009 to December 31, 2011

The goal of this project was to design a DiffServ-based method allowing the application to participate in a classification process. The work continued with the definition of a universal mechanism allowing applications to properly express their requirements for network resources and to forward this information to the communication network. The results significantly contribute to developing sophisticated network services with a more efficient use of network resources and offering a higher service quality.

Research into and Development of Systems for Manufacture Optimization

Project of the Ministry of Industry and Trade no. FR-TI1/444

Duration: from April 1, 2009 to July 30, 2013

The objective of this project is applied research and the development of a system for the optimization of business processes in manufacturing organizations. The system should be able to automatically optimize the customer's business process.

Media-informatics System Supporting Advanced Multimedia Services

Project of the Ministry of Industry and Trade no. FR-TI2/679

Duration: from March 1, 2010 to December 30, 2013

The project is focused on the design and operation verification of the functionality of a new product – a media-informatics system – intended to provide advanced multimedia services. The content management system is the basis of the solution. It will be adapted to the management of multimedia files with advanced searching operations based on speech, image and text recognition in multimedia files. Also, the system is to contain a module for easy establishment of videoconference sessions within both fixed and wireless networks, with the possibility of recording videoconference sessions and their safe archiving.

Adaptable Wireless Sensor Networks with Data Visualization for Crisis Management

Project of the Ministry of Industry and Trade no. FR-TI2/571

Duration: from March 1, 2010 to December 30, 2013

Applied research and the development of adaptive wireless sensor networks with data visualization for crisis management of villages and towns.

Research into a Modular System for Communication Technology and its Verification on a 2N Communication Server

Project of the Ministry of Industry and Trade no. FR-TI2/220

Duration: from January 1, 2010 to December 30, 2013

The goal of the project is to create a modern modular communication system which is able to integrate the most popular communication protocols with a simple user interface. The project is focused on the invention of a software product which is independent of specific hardware.

Multifunction Programmable Infusion Pump for Patient-controlled Analgesia (PCA) with Telemonitoring Option and Attachment to the Hospital Information System

Project of the Ministry of Industry and Trade no. FR-TI3/234

Duration: from January 1, 2011 to December 30, 2013

The project concerns a complex solution of patient-controlled analgesia, using the multifunction programmable PCA pump with full connectivity to database servers and hospital information systems. The project goal is to integrate all demands on the processes of analgesics dosage while ensuring the safety of patients, staff and processed data.

Applied Research and the Development of Systems for Remote Quality Measurement of Power Supply

Project of the Ministry of Industry and Trade no. FR-TI1/075

Duration: from April 1, 2009 to December 30, 2012

Development of instruments for power quality measurement for the AMM and AMR systems suitable for remote metering and management. Identification of a suitable communication system for remote meter reading and analysis, and verification of the suitability of PSTN and GSM networks and PLC technology for the transfer of data measured to the central telemetric station.

Intelligent Video-modules for Systems of Controlling Entry to Critical Infrastructure Facilities

Project of the Ministry of Industry and Trade no. FR-TI3/170

Duration: from January 1, 2011 to December 30, 2014

Research into and development of a modular system with external and internal intelligent video-modules for an entry control system with face identification, anti-tailgating, compliance with behavioural and safety rules, and visualizing on a map the movement of people about a facility, and an experimental verification of the system.

5 Programme of Multimedia Systems

Prof. Zdeněk Smékal, smekal@feec.vutbr.cz

Research of the programme is focused on sophisticated preprocessing of signals to be transmitted by the communication system, and on the digital processing of signals to be delivered to an end user (acoustic signals, static and dynamic images, interaction of the user and a communication device, assessment of emotions for call centres, etc.).

Audio and video processing in communication networks

- Design of algorithms for the transmission and processing of audio and video signals and the development of its individual parts.
- Development of algorithms for compressing audio and video signals according to the MPEG and JPEG standards, quality measurement of compressed signals according to ITU-T P.862, P.563, etc.
- Development of algorithms for the reconstruction of noisy or damaged audio and video signals using linear and nonlinear digital filtering, adaptive filtering, spectral subtraction, etc.
- Development of algorithms for processing multichannel audio signals – shaping the directional characteristics (beam-forming), blind separation (blind source separation), analysis of independent or principal components (ICA, PCA).
- Research into and development of algorithms for reconstructing noisy or damaged audio and video signals using modern orthogonal and non-orthogonal transforms – wavelet transform, x-lets, frame, etc.
- Development of specialized image processing algorithms: inpainting, extrapolation (i.e. filling in the unknown borders of an image), interpolation, customized compression algorithms for specific types of data (faces, fingerprints, geometric structures, etc.).

Development of an interactive gestural human-machine interface

- Development of algorithms for gender and age recognition from speech signal parameters.
- Development of algorithms for automatic analysis of emotional state of a human from audio-visual data.
- Development of algorithms for automatic analysis of emotional content in written text.
- Development of algorithms for interactive control of the real-time processing of multi-media signals.

Development of biometric systems

- Development of algorithms for speaker recognition and verification using information extracted from the speech signal.

- Development of algorithms for face recognition and person identification from the image signal.
- Development of biometric systems based on fingerprints, faces, etc.

Processing of biomedical signals

- Research into algorithms for automatic diagnosis of neurological disorders, e.g. Parkinson's disease, from speech signal parameters.
- Development of algorithms for automatic detection of speech defects from speech signal parameters, and for helping in practising their removal.
- Development of algorithms for automatic processing of image signals acquired using X-rays, magnetic resonance or computer tomography.
- Research into and development of algorithms for image content enhancement.
- Research into and development of algorithms for spatial analysis of data from computer tomography and magnetic resonance.
- Research into and development of algorithms for processing ultrasound images and video sequences (automatic detection of specific shapes and analysis of geometric parameters and their time dependence).
- Development of fast methods for capturing magnetic resonance data, using compressed sensing.

Development of embedded systems

- Design of embedded multimedia systems, design and development of their particular parts.
- Development and optimization of real-time algorithms for digital signal processors with the Harvard architecture – the DSP56300, DSP56700, MC56F8300, and TMS320C5500 series.
- Development and optimization of real-time algorithms for digital signal processors with type VLIW architecture – the TMS320C6400, TMS320C6700, and MSC8100 series.
- Development and optimization of real-time algorithms for processors with the ARM architecture – the PXA2xx, ColdFire, OMAP, and Kinetis series.
- Development and optimization of algorithms for general-purpose processors with parallel and multi-threaded architecture with multiple approaches.
- Development of drivers of multimedia-specific circuits for the Windows or GNU / Linux embedded operating systems.

Smart camera systems

- Research, development and design in the area of detection and classification of patterns in images and video sequences (face, figure, gestures, walking or other features).
- Research, development and design in the area of tracking the parameters and positions of given patterns in a video sequence.

- Research, development and design in the area of recognition of a dangerous content in images and video sequences.

3D acquisition and display

- Research, development and design in the area of stereoscopic acquisition of a 3D scene using the latest camera equipment.
- Research, development and design in the area of editing, cutting and mixing stereoscopic records.
- Research, development and design in the area of 2D → 3D real-time conversion, creation and editing of accurate 3D scene models including textures, 3D scene reconstruction based on correspondences, spatial camera calibration.
- Research and development in the area of auto-stereoscopic display.

Systems working in the infrared (thermal) spectrum

- Accurate acquisition of images of thermal distribution in a scene.
- Analysis of thermal distribution in an image, segmentation and detection of objects or regions, based on both the local temperature and the shape.

Room acoustics

- Room acoustics and sound quality measurement using a head-and-torso simulator.
- Development of algorithms for auralization and room acoustics simulation.
- Development and testing of algorithms for sound source panning and distance rendering in multichannel sound systems.

Noise measurement and analysis

- Industrial and environmental noise measurement, measurement using the Doppler laser, post-processing and analysis of the data measured.
- Noise source identification using near-field acoustic holography and beam-forming.
- Measurement of acoustic intensity and power using the intensity probe.

Design and measurement of electroacoustic and audio devices

- Design and realization of analogue and digital interfaces for audio signal processing systems.
- Measuring the characteristics of electroacoustic transducers, loudspeaker systems, sound reinforcement systems, etc. in the anechoic chamber.
- Rapid testing of electroacoustic devices, evaluation of possible structural defects which manifest themselves in the acoustic characteristics of the particular device.
- Measuring the telecom terminals, headphones, mobile phones, headsets, etc.
- Measuring the characteristics of analogue and digital audio devices.

Sound field analysis and synthesis

- Analysis of acoustic intensity distribution using near-field acoustic holography and beam-forming.
- Algorithm development for sound field analysis and synthesis using spatial impulse response rendering, directional audio coding, ambisonics, and wave-field synthesis.

Real-time audio signal processing

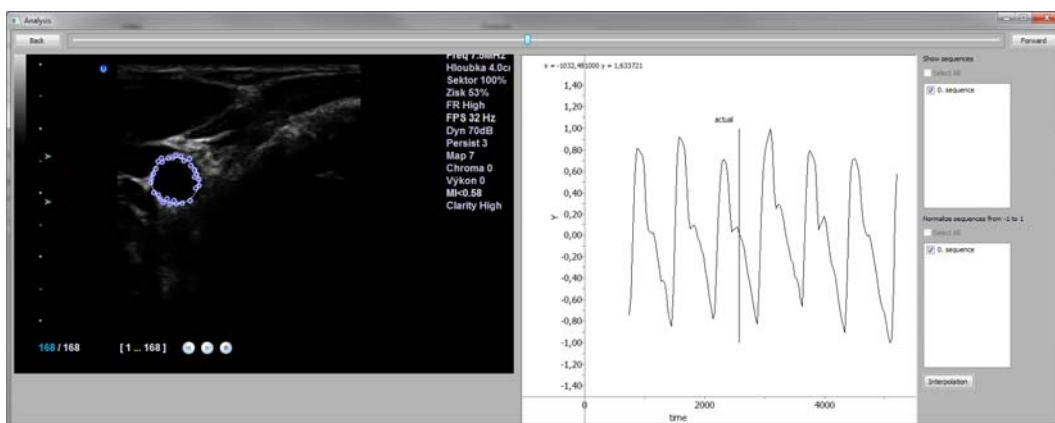
- Development, realization and experimental verification of customized systems for real-time multichannel processing of audio signals
- Software development for remote control of these systems using the Internet.
- Design, optimization, and implementation of algorithms of real-time audio signal processing in general desktop, embedded, and signal processors including the implementation of plug-in technologies.
- Design of real-time audio processing algorithms using wavelet transforms.



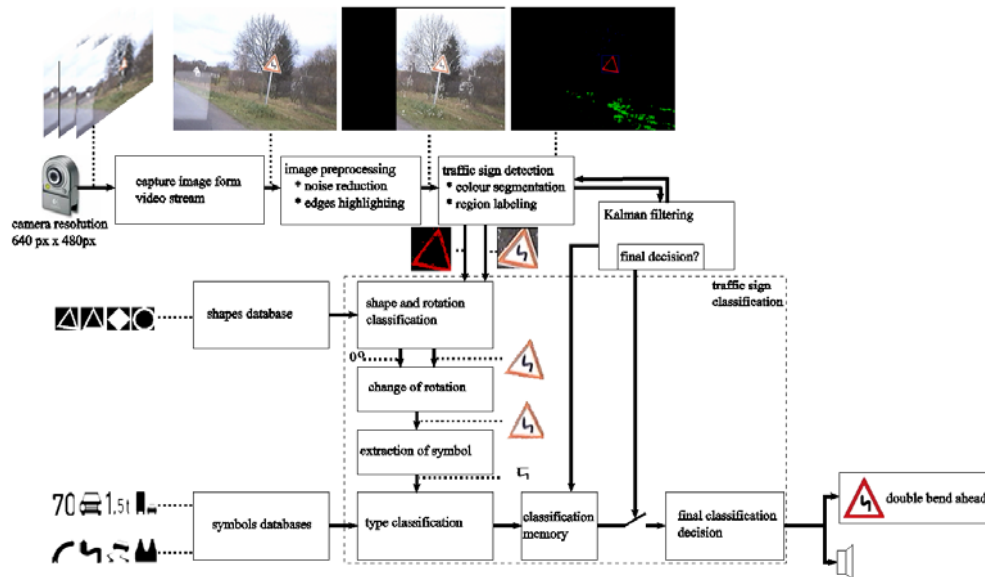
Experimental facility for recording speech signals, installed in the speech therapy clinic. In addition to the recording equipment, there are absorption panels reducing the reverberation time in the room. The workplace was utilized within the project FT-TA2-072 *Research and application of time-frequency analysis in speech therapy, foreign language teaching and teaching the deaf to speak* for the recording of test speech sequences with speech defects.



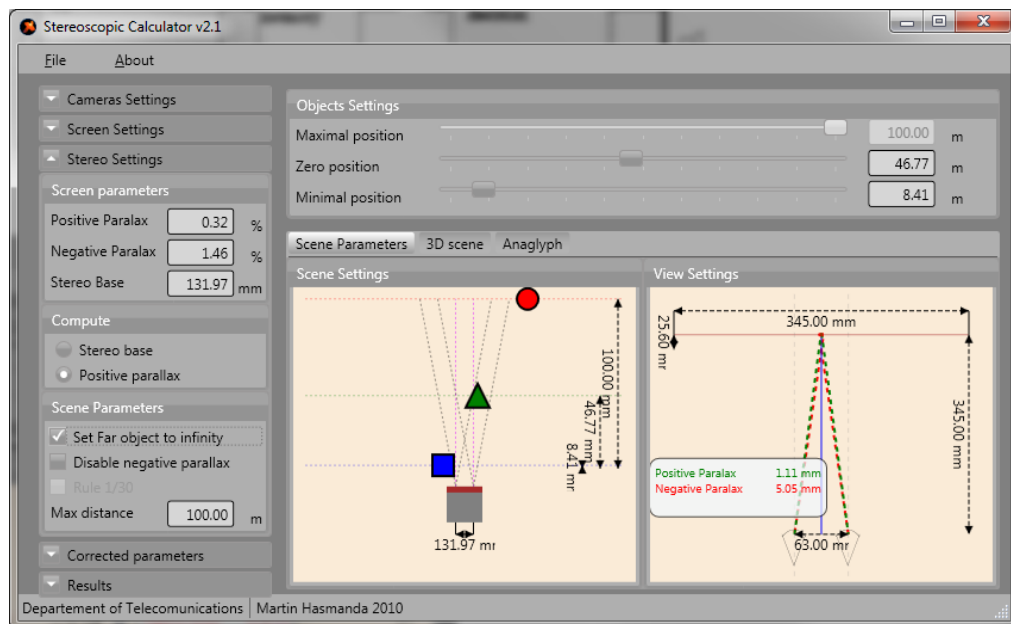
Sample of a control module with PXA270 processor with ARM architecture and a subscriber module with Si3220 SLIC circuit. The sample was developed within the project FT-TA3/011 *Research and development of IP compatible private branch telephone switchboard* for the development and testing of Si3220 driver for the GNU / Linux 2.6.21 operating system kernel. The debugged driver is used for connecting analogue telephone lines in the prototype of an Internet telephone exchange.



The figure presents **an example of a window as a part of the utility model *Equipment for analysis of spatially varying objects***. The results of processing an ultrasound video sequence which contains an artery in a perpendicular cut are depicted. The right part of the figure presents the output of processing: the extracted cardiac cycle curve. This utility model is one of the results of project no. 2B06111 *New Diagnostic Methods for Establishing the Circulatory System Parameters, Based on Infra-Red Scanning of Blood-Vessel Images*.



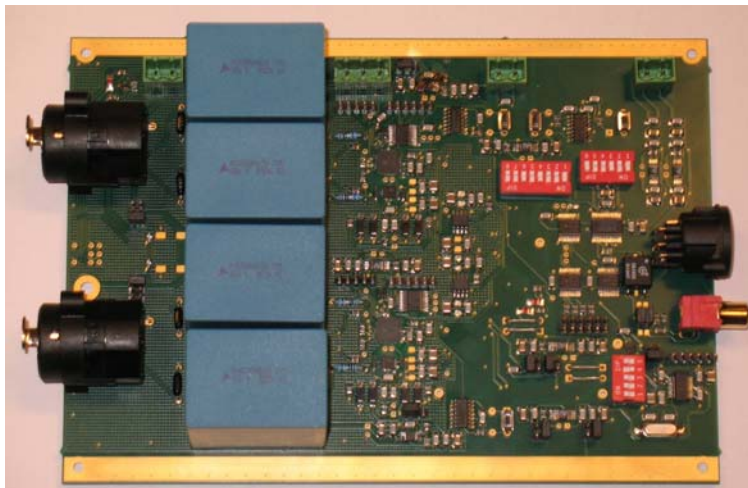
Block diagram and example of the output – detection and recognition of road signs in a video sequence.



Graphical user interface of the application *Stereoscopic Calculator*, which could be used for the simulation of configuration parameters in stereoscopic image acquisition.



Main window of remote-controlled application for automatic audio broadcast surveillance.



Remote-controlled, high-quality, two-channel input block of the audio interface for embedded PC.



Application for remote control of systems of real-time digital audio signal processing.

Selected research and development projects

New Diagnostic Methods for Establishing Circulatory System Parameters Based on Infra-red Scanning of Blood-vessel Images

Project of the Ministry of Education no. 2B06111

Duration: from July 1, 2006 to June 30, 2011

The research proceeded in two directions: an analysis of pressure changes based on changes in pulse wave velocity, and an analysis of dynamic changes in a tissue segment from ultrasound video-recording. Furthermore, a number of experiments based on ultrasound scanning of images and image sequences of arteries and an evaluation of their dynamic changes were carried out. The research work led to novel solutions in both areas.

Multiply Utilizable System for Processing Digital Multimedia Signals

Project of the Ministry of Industry and Trade no. FR-TI1/495

Duration: from July 1, 2009 to December 31, 2012

The project is focused on applied research and experimental verification of a multiply-utilizable system for digital processing of multimedia signals in real time, with low cost, capable of reconfiguration and remote management via TCP/IP networks. The system consists of a software technology for the reconfigurable and remotely controllable part, as well as its respective implementation platform, which is an embedded system with a general purpose processor, with a top-quality multichannel audio interface, and with communication interfaces supporting networks using TCP/IP.

Audio Broadcast Surveillance

Research contract for D.F.M. GmbH and TC Electronic A/S

Duration: from February 1, 2006 to December 31, 2009

Within the project, special software for automated surveillance, failure detection and quality measurement in audio broadcasting was developed. The software can be remote-controlled and integrated into professional monitoring systems for radio broadcasting stations.

Research into and Application of Time-frequency Analysis for Speech Therapy, Teaching Foreign Languages, and Teaching the Deaf to Speak

Project of the Ministry of Industry and Trade no. FT-TA2/072

Duration: from January 10, 2005 to May 31, 2009

The project was focused on the research into modern methods of speech signal analysis. These methods were then used to design an automatic system for detecting wrong pronunciation that will be used in speech therapy.

Intelligent Video-modules for Systems Controlling Entry to Critical Infrastructure Facilities

Project of the Ministry of Industry and Trade no. FR-TI3/170

Duration: from January 1, 2011 to December 30, 2014

The project is focused on the research into and development of video analytic modules for face recognition, anti-tailgating, behavioural tracking, safety rule compliance checks, and tracing persons on a facility map for systems controlling entry to critical infrastructure sites (such as power plants).

Improvement of Risk Area Security using Combined Methods for Biometrical Identification of Subjects

Project of the Ministry of the Interior no. VG20102014033

Duration: from September 1, 2010 to August 31, 2014

The goal of the project is to integrate the combined biometrical methods into an existing camera system structure for public and private risk area security. Such improved systems will allow an easier detection of potential threats, by implementing the methods for automatic subject identification from face, voice, body shape and movement, and other biometrical features. The methods for the emotional analysis of speech and video signals enable preventive searching for aggressive subjects.

6 Programme of Sensor Systems

Prof. Radimír Vrba, vrbar@feec.vutbr.cz

Research in this programme is focused on the investigation of advanced sensor systems, analysis of appropriate diagnostic methods for complex testing of such systems, and the design of ordered nanostructures of various shapes on nanosensor electrodes. Attention is turned to the investigation of the magnitude and sensitivity of signals, including their transmission and evaluation. The research programme likewise includes the development of new methods for the diagnostics and characterization of materials and electrical components, which is necessary to meet new requirements for the sensing of both electrical and non-electrical quantities.

The research programme offers R&D services in the following areas:

Sensors

- Development of microsensors based on semiconducting metal oxides for gas detection.
- Development of systems for micro-machined sensors.
- Development of chemical sensors and biosensors for environmental and diagnostic applications, the use of markers for the diagnosis of cancer.
- Development of "wearable" sensors and wireless communication systems.

Nanostructures

- Development of a system of nanoelectrodes for various applications.
- Development of nanostructured surfaces with improved properties such as regular structure, increased area, hydrophobic surfaces, and nanofibres.
- Development of porous membranes for separations, nanofluidics, and sensor technology.
- Nanolithography for the transfer of any motives into thin material.

Full-custom integrated circuit design

- Discrete-to-integrated solution.
- Oriented to sensor applications and signal processing.
- System modelling and transistor-level simulation in CADENCE.
- Synthesis of digital systems and gate-level netlist analysis.
- Physical design of ASIC.
- Complex digital HDL-to-ASIC design.

Sensor and IP networks

- Localization of nodes in wireless sensor networks without using GPS.
- Localization of nodes in IP networks without using GPS.
- Energy-effective data transmission in wireless sensor networks.

- Testing of the communication reliability in wireless sensor networks based on the IEEE 802.15 standard.

Characterization of materials and structures

- Local optical and electronic characterization of optoelectronic structures with a lateral resolution better than 250 nm (topography, local changes of material constants, local photocurrent, photoluminescence and electroluminescence).
- Dielectric characterization of materials, i.e. solids and liquids, with thickness ranging from 1 μm up to 10 mm in a frequency range of 1 kHz – 1 GHz and in a temperature range of 20 K – 500 K.
- Elementary characterization of semiconducting material and components in a temperature range of 10 K – 400 K by using a wide spectrum of laboratory equipment - HP 4284A and HP4285A impedance analyzers, Agilent E4991 analyzer, Agilent 35670A signal analyzer, Keithley 4200 Semiconductor Characterization System, etc.
- Characterization of passive components in a temperature range of 10 K to 400 K.
- Measurement of the distribution of surface potential on a material structure.
- Experimental evaluation of structural parameters such as charge carrier concentration, mean lifetime, PN junction type, development of the concentration of additions in PN junction, diffusion voltage, and width of the depletion zone.
- Diagnostics of structure quality (local and bulk defects, contacts) and study of structural parameters both in standard conditions and in extreme thermal conditions.
- Development of new methods and new instruments for material characterizations.

Performing of loading tests and diagnostics of materials under loading

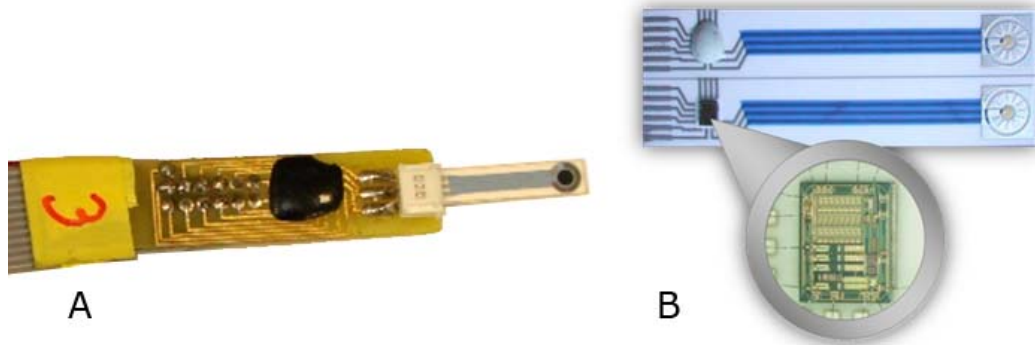
- Diagnostics of micro-crack initiation inside nonconductive materials and electrical components in laboratory conditions (at predefined thermal or mechanical loading)/operational conditions by using electromagnetic and/or acoustic emissions.
- Artificial aging via long-term thermal cyclic loading.
- Accelerated aging using the method of current pulses.

Optimization

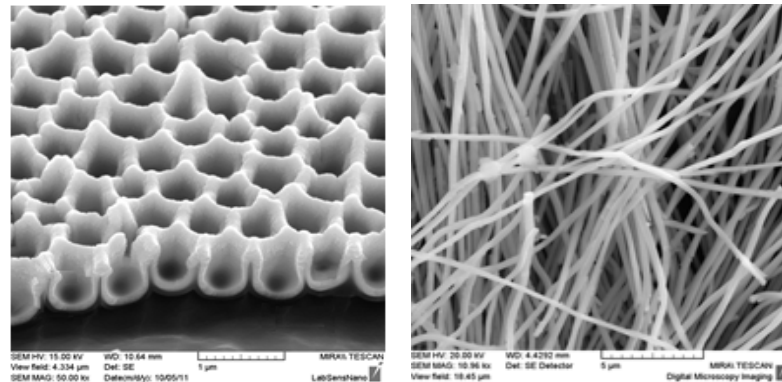
- Development of physical models of components and sensors to optimize their parameters.
- Optimization of signal-to-noise ratio of sensors on the basis of electrical and noise characteristics.

Measurement

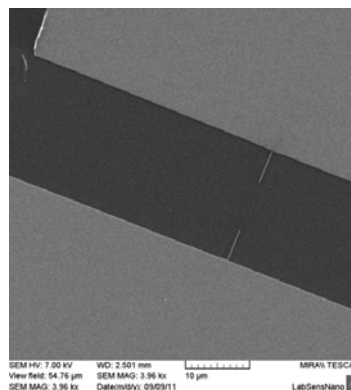
- Measurement of the time dependence of noise voltages and noise currents.
- Measurement of noise spectral densities.
- Measurement of voltage and current dependence of the RMS value of narrowband noise current.
- Transport characteristics measurement, VA characteristics with a voltage source or a current source, CU characteristics up to 600 V.



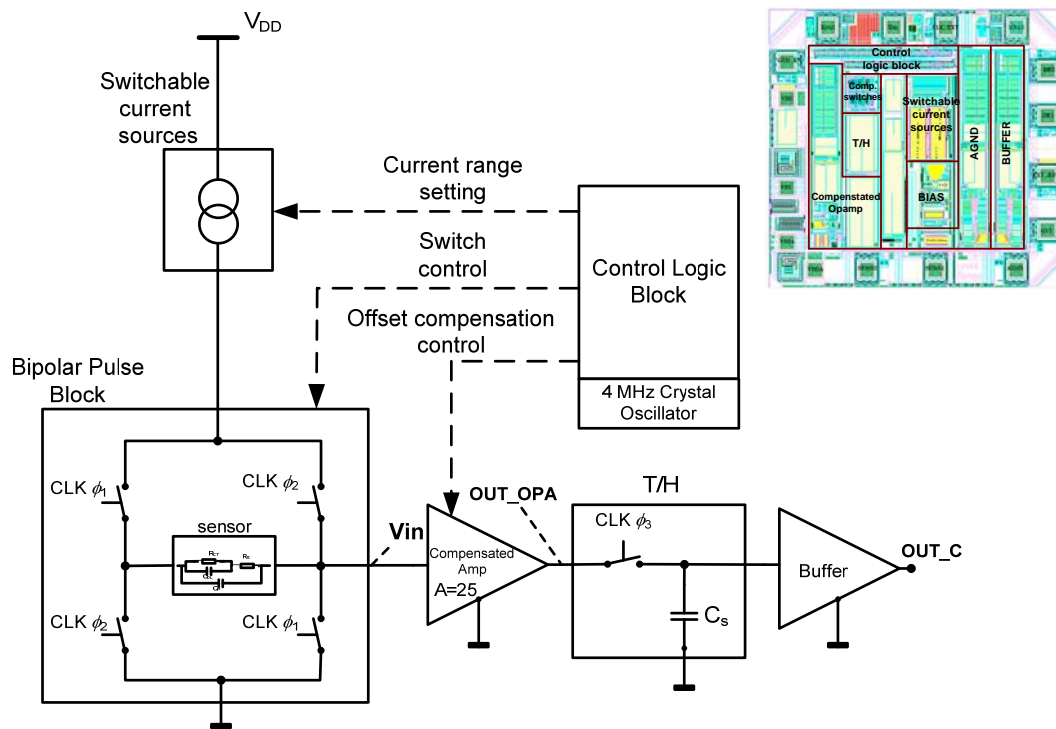
Electrochemical sensor with microchip potentiostat (A) embedded in the connector, (B) integrated directly into the printed electrodes.



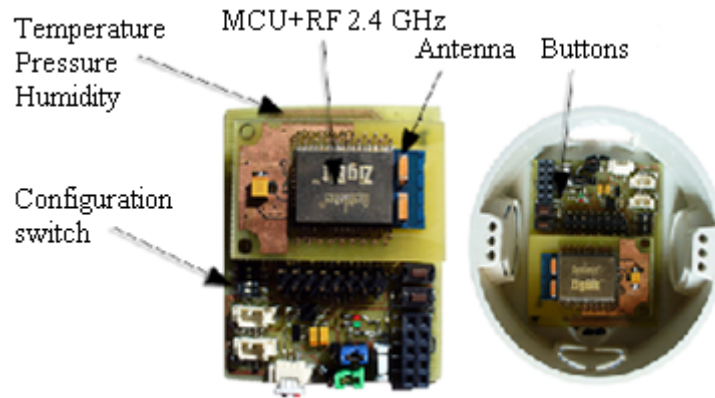
Nanostructured surfaces of various materials: porous dielectric materials and metal nanowires created within the SoMoPro project.



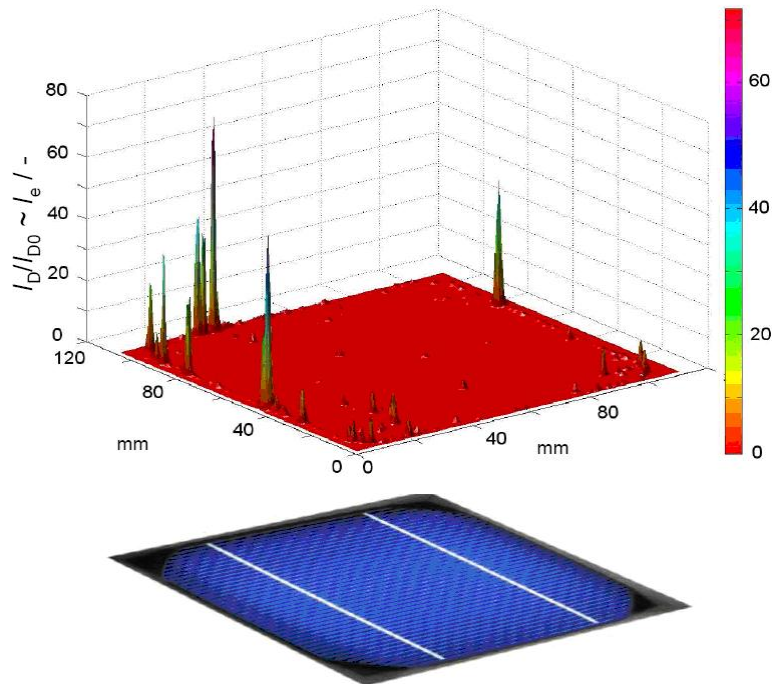
Nanowire electrodes in a gold layer created for the Institute of Physics of the Czech Academy of Sciences in Prague.



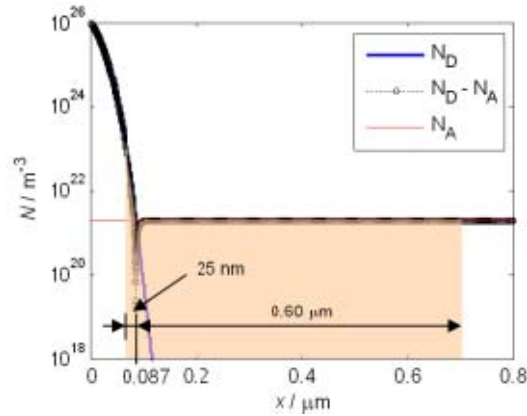
The ASIC proposed for the current bipolar method of the sensor conductivity measurement was designed and manufactured in AMIS CMOS 0.7 μm technology. Direct and alternative methods can be used for measuring the conductance of water solutions. As is known, the direct method is absolutely unsuitable in consequence of the cell behaviour as a serial capacity. The other important limitation is the voltage amplitude that must be lower than 100 mV because of the potential appearance of electrolytic processes. The technique of the bipolar pulse belongs to methods for high-precision measurement. The circuit architecture is designed to measure the sensor conductivity almost independently of the opamp offset and switch resistance applied.



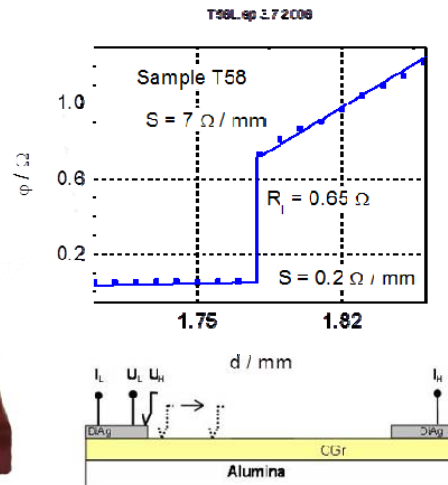
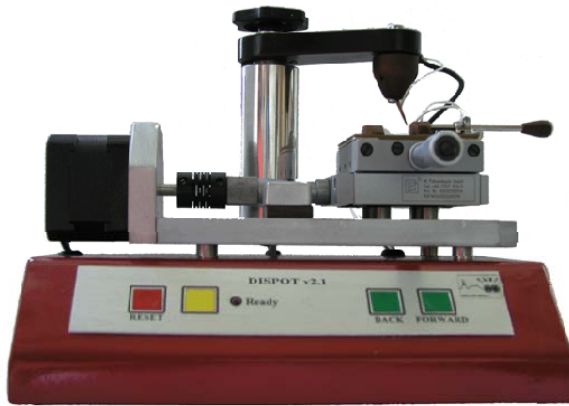
The prototype of a sensor node for energy-efficient wireless transmission. The sensor node can be used for a sensor network deployment based on the ZigBee standard. It operates with pressure, humidity and temperature sensors (connection of other sensors is possible). The sensor node was developed in order to achieve the lowest possible energy consumption to maximize its service life.



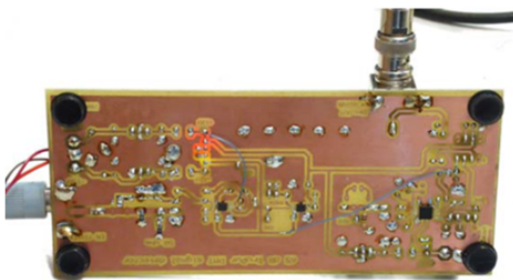
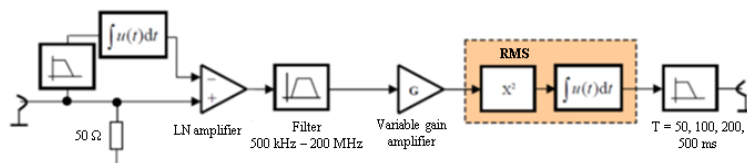
Localization of light emission from reversed biased solar cell PN junction. The research was supported by the project of the Czech Science Foundation no. GA102/10/2013 *Fluctuation processes in PN junctions of solar cells.*



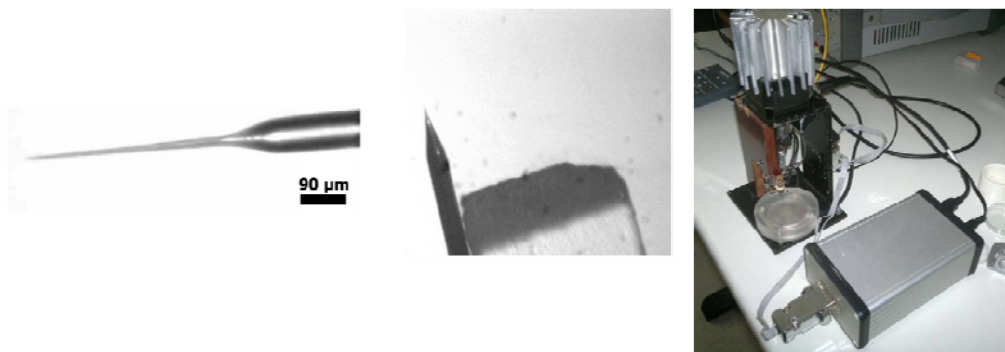
Simulation of a PN junction. The model was developed during an investigation of solar cells. The concentration profile in both parts of the space charge region is obtained via an experimental study of barrier capacitance. The parameters are: $N_a = 1.1 \cdot 10^{21} \text{ m}^{-3}$, $N_0 = 10^{26} \text{ m}^{-3}$, $D = 5.8 \cdot 10^{-20} \text{ m}^2 \text{ s}^{-1}$, $t = 3600 \text{ s}$



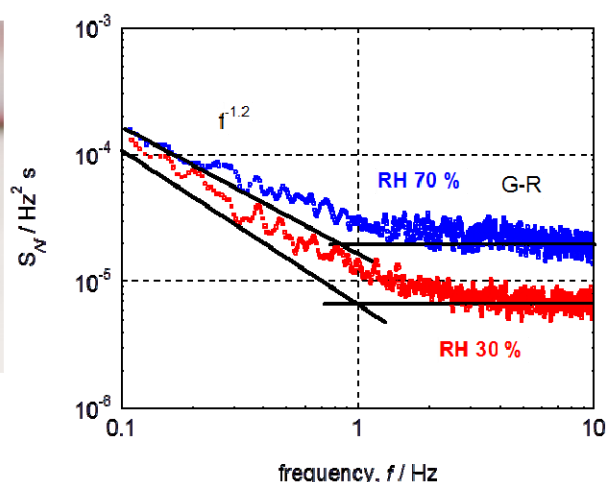
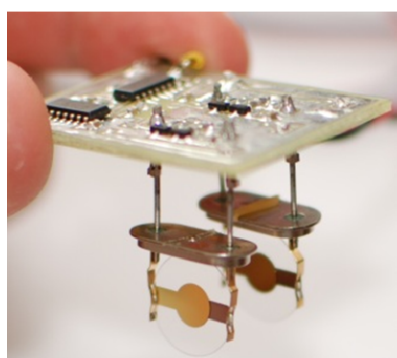
Design, development and manufacture of the DISPOT instrument for the measurement of surface potential distribution on a material structure. Surface potential distribution along the polymer-based thick film resistor.



Characterization metrology. Nondestructive registration of photon emission from defective (abnormally loaded) areas of semiconductors.



Submicron etching of SPM tips. Application in the measurement in the near-field by using optical fibres and conductive coated tips for AFM microscopy.



Development of a mathematical model that describes fluctuations of chemical processes on the sensor interface, and design of a measurement system for gas-based quartz crystal microbalance in the framework of the KONTAKT ME896 project *Piezoelectric sensors for biological agent detection: Optimization of signal to noise ratio.*

Selected research and development projects

New Design and Application of Nanobiosensors and Nanosensors in Medicine (NANOSEMED)

Project of the Czech Academy of Sciences no. KAN208130801

Duration: from January 1, 2008 to December 31, 2012

The project aims to create new and original designs of a monogenic or heterogeneous nanosystem such as a nanobiosensor and nanosensor for medical applications. With further advances in medical technologies, on-line monitoring of both the physiological parameters of an individual and the therapy effect has come to the fore; it consists in monitoring the level of glucose, cytostatics or other medicines or in a simple and quick analysis of biologically important proteins (p53, p21, metallothionein, glutathione, rb protein, etc.) and sequences of nucleic acids (gene for cystic fibrosis and others). Nanosensors and nanobiosensors using materials with unique physical-chemical properties can bring significant progress in the detection

of biologically and clinically important compounds. Furthermore, greater attention will be paid to magnetic materials suitable for the separation of such compounds. The procedures will enable an easy and selective detection and separation of the biomolecules and compounds sought.

Miniaturized Intelligent Systems and Nanostructured Electrodes for Chemical, Biological and Pharmaceutical Applications (NANIMEL)

Project of the Czech Science Foundation no. GA102/08/1546

Duration: from January 1, 2008 to December 31, 2012

The project is based on examining how to obtain nanostructures of various materials (e.g. Bi, Ga, Galinstan) on planar microelectrodes, which form the sensitive parts of electrochemical sensors, with the goal of reaching high sensitivities in electrochemical analyses such as heavy metal detection, and in the research into bioactive materials for the modification of microelectrodes such as affinity layers in the analyses of biomolecules. Together with the microchip developed for microelectrodes and for target applications, a miniaturized portable system for field and laboratory measurement will be built. The microelectrodes with nanostructures will be integrated into a sensor array together with the intelligent integrated electronic system developed. This unique portable device enables conducting many different analyses in a short period of time, using various methods and electrodes (e.g. the analysis of proteins, DNA, etc.), which leads to a higher effectiveness of the research work in electrochemical analyses.

MAS – Nanoelectronics for Mobile Ambient Assisted Living (AAL) Systems

Project ENIAC Joint Undertaking no. 7H10021

Duration: from April 1, 2010 to March 31, 2013

<http://www.mas-aal.eu>

The objective of MAS is to develop a common communication platform and nanoelectronic circuits for health and wellness applications to support the development of flexible, robust, safe and inexpensive mobile AAL systems, to improve the quality of human life and to improve the well-being of people. In this context, reference architectures will be defined in order to enable system development from devices to complete mobile AAL systems, and to enable forming cooperative clusters of such systems for specific environments and applications.

E3CAR Nanoelectronics for Energy Efficient Electrical Car

Project ENIAC Joint Undertaking no. 7H09009

Duration: from March 1, 2009 to February 29, 2012

<http://www.e3car.eu>

The project is financed by the EC in 16.7% and by the Czech national contribution in 83.3%. The objective of the project is the development of nanoelectronic technologies, devices, circuit architectures and modules for electrical cars/vehicles, and the demonstration of these modules in the final systems. The E3Car project aims to increase energy efficiency in the mobility by more than 35% compared with the existing technologies.

Novel Intelligent Submicron Structures and Microsystems for Advanced Microsensors

Project of the Czech Science Foundation no. P102/11/1379

Duration: from January 1, 2011 to December 31, 2013

The fundamental research problems of the proposed grant project belong to a wide and very promising area of microelectronics – mixed analogue and digital circuits on the basis of the CMOS technology. In this permanently expanding area the project is oriented towards fundamental research into new intelligent sub-micron structures and microsystems for advanced microsensors. The design methodology of these sub-micron structures and SoC circuits is the subject of great attention in the scientific community, especially in conjunction with the need for new applications, new circuit building blocks and progress in technology, which can significantly simplify this process and also remarkably improve the properties of the designed circuits and systems.

Feedback Distribution Framework for Single Source Multicast

Project of the Czech Science Foundation no. 102/07/1012

Duration: from January 1, 2007 to December 31, 2009

This project dealt with hierarchical feedback aggregation from a large number of receivers to the sender when source-specific multicast is used. Using this method, transmission speeds can be achieved that are up to several hundred times higher than those achieved by currently used technologies. The main project outcome was a new communication protocol called TTP (Tree Transmission Protocol). It was designed to organize the nodes involved into a tree structure for feedback transmission. The features of the proposed protocol were evaluated using simulations and also in the real world-wide experimental network PlanetLab (www.planet-lab.org). The investigation into feedback transmission from a large number of nodes was further extended into wireless networks.

Research and Development of Progressive Instruments for Enhancing the Surface Quality of Cast Billets, Bars and Wires

Project of the Ministry of Industry and Trade no. FR-TI2/536

Duration: from January 1, 2010 to December 31, 2012

The project focused on the appearance of surface defects of cast billets in relation to the production parameters of processing and continuous casting of pearlitic steels, spring steels, free-cutting steels, micro-alloyed steels and carbon steels.

Application of Laser Technologies into the Process of Crystalline Silicon Solar Cells Production

Project of the Ministry of Industry and Trade no. FR-TI1/305

Duration: from July 1, 2009 to June 30, 2013

The application of laser technologies in the manufacture of solar cells is one of the ways how to increase the cell efficiency; it simultaneously helps to decrease the processing times. Laser processes are largely suitable for selective layer struc-

turing, dicing, scribing and drilling. This project deals with research into the laser treatment of silicon substrate and its optimization for industrial purposes. The project is focused on the transfer of R&D knowledge into the design and construction of the prototype of a multi-purpose device for laser processes on an industrial scale.

Electron Transport, Noise and Diagnostics of Schottky and Auto-emission Cathodes

Project of the Czech Science Foundation no. P102/11/0995

Duration: from January 1, 2011 to December 31, 2013

The project deals with electron transport, fluctuation phenomena and non-destructive diagnostics in Schottky and auto-emission cathodes. The aim is to study the properties and behaviour of layers of tungsten and noble metal layers formed in the course of etching the auto-emission cathode. The project focuses on the stability of electron emission, V-A and noise characteristics and emission divergence. The methodology is based on the analysis of noise spectral density at different vacuum levels, temperatures and electric field strengths. AEC feature some advantages over thermionic cathodes, such as high current densities, good divergence and low costs; hence, they contribute to the development of vacuum electron sources for electron microscopes with submicron resolution. Their performance depends on oxide thickness, tip dimensions, electric field strength, and vacuum levels.

Local Optical and Electronic Characterization of Optoelectronic Structures with Nanometric Resolution

Project of the Czech Science Foundation no. 102/08/1474

Duration: from January 1, 2008 to December 31, 2010

The project focused mainly on the study of silicon single-crystal solar cells, which were of various surface textures. Two important aspects were studied: 1) existence of light emission spots that are of micrometre and nanometre sizes. In the structure of solar cells, these spots represent defects that decrease the efficiency of light-to-electricity conversion; 2) thermal dependence of light emission varying with the defect location. Light emission changes its parameters for defects on the edges and in the bulk of the cell.