

C H R O N I C L E

**The 57th Open Seminar on Acoustics OSA'2010**  
**Gliwice, Poland, September 20 – 24, 2010**

Traditionally you are invited to acquaint with some abstracts of lectures, submitted for presentation in 57th Open Seminar on Acoustics (OSA'10). This national Seminar, with some foreign guests, in this year is organized by Upper Silesian Division of the Polish Acoustical Society, with cooperation of Institute of Physics – Science-Didactics Center at Silesian University of Technology and Acoustics Committee of Polish Academy of Sciences. In this year OSA'10 will take place in Gliwice at the Congress-Educational Center of the Silesian University of Technology. The conference has two famous honorary patrons – the Magnificence Rector of the Silesian University of Technology, Prof. Andrzej Karbownik, and Ministry of Science and Higher Education, Prof. Barbara Kudrycka.

The Seminar is a forum for all fields of acoustics. Particularly in this year, in the Seminar Program you can find the following topics: general acoustics, environmental acoustic, biomedical acoustics, acoustics in blind person's life, active noise control, acoustical emission, vibroacoustics, ultrasound, interior acoustics and others. During the Seminar, the theoretical works, experimental, measuring, technical, applied and normative ones are presented.

All the lectures prepared for OSA'10 are published in the "57th Open Seminar on Acoustics Materials" – in book form and on cd. This publication is intended for participants of the Seminar and for many libraries in Poland. After acceptance by reviewers, the extended form of some lectures will be published in *Archives of Acoustics*.

Once again we have decided to organize this conference, taking into account the fact that it is an important event for acousticians and other Polish and foreign scientists. We hope that this conference program will gain acceptance and respect among its potential participants. We count on your numerous response and active participation.

The Seminar is traditionally sponsored by the Ministry of Science and Higher Education.

Further information about OSA'10 you can find at <http://ogpta.polsl.pl/osa>.

On behalf of the Organizers  
*Roman Bukowski*  
Chairman of the Organizing Committee

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## Abstracts

### 1. Active noise control with variable step-size LMS algorithm

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LMS algorithm is most commonly used in active noise control (ANC) applications. The algorithm is easy to implement, fast and robust. However, it requires careful step size adjustment. Large step-size, although valuable for fast adaptation, results in large excess mean square error. Small step size allows for good attenuation, but also means slow adaptation. Therefore, many step-size algorithms can be found in the literature. This paper presents a new contribution in this field. The algorithm presented below is based on a new LMS stability condition, developed without the small step-size assumption. The algorithm aims at fast adaptation, necessary to preserve high attenuation during fast changes in the acoustic environment, e.g. when the person moves in a room. The algorithm is computationally inexpensive and proved to be efficient during simulations as well as during laboratory tests.

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### 2. Loudspeaker methods for surround sound

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Available methods for room-related sound presentation are introduced and evaluated. A focus is put on the synthesis side rather than on complete transmission systems. The following methods are described and compared: amplitude-difference stereophony (Intensity Stereophony), Vector-base Amplitude Panning (VBAP), 5.1-Surround, synthesis with spherical harmonics (Ambisonics), synthesis by means of the boundary method (Wave-field Synthesis, WFS) and binaural-cue selection methods (e.g., DIRAC).

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### 3. The technical possibilities of reducing the acoustic pressure level generated to surroundings by the power transformer

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The subject matter presented in the paper refers to measurements and assessment of the corrected acoustic pressure level (noise) values occurring around a medium-power transformer.

The paper presents the values of the noise accompanying operation of the power object before and after its modernization, which consisted in repeated core pressing and replacement of the cooling system. The main aim of the research work was the assessment of influence of the repair work on the noise level emitted into the environment.

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#### 4. The way of seabed surface spatial visualization

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Each of hydroacoustic devices used both for investigations and for navigation, co-operates with appropriate software to record and data visualization. As known, these systems may differ significantly in these parameters and function. The most important parameters which influence the kind of application is frequency, sounding pulse length, beam or beams width and acoustic power. These variables decide on their destination (local water depth, object localization in water, seabed visualization or sediments structure). Each of these systems is connected with convenient visualization. In case when there are many different hydroacoustic devices installed in a vessel, presentation of all data in common visualization is comfortable for the user.

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#### 5. Noise map of a small urban area. Case study

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The paper investigates the problems of analysis and evaluation of acoustic climate of a small town, in relation to statutory requirements posed in this regard by large urban agglomerations. The existing methodologies and regulations, relating to large cities, may not be directly applied to a small town, therefore the paper presents a modified approach, incorporating specific conditions that existed in these cities, sometimes dominated by acoustic noise sources, do not occur in large cities. As a part of the work were selected and characterized the main sources of noise, shaping the acoustic landscape Grybów. According to the modified methodology, noise measurements were performed to verify the developed acoustic model of the town. For the purposes of model calculations made digital terrain model, a particularly important given the location of the city in a mountainous, heavily varied terrain. The modeling and mapping of LN, LDEN indicators and in addition LD, allow for full parameter setting and evaluation of acoustic landscape of the city; on the other hand, they can provide an important guidance and even patterns and mapping solutions for small acoustic cities, with generally quite strongly resource-limited input data.

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## **6. Diagnosis of the non-concurrent operation of the on-load tap changer contacts by the acoustic emission method**

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On-load tap changers (OLTC) are some of the main transformer elements that make the voltage adjustment in a power network possible. Their failures often cause shut-downs of distribution transformers. The paper presents the research work results, the aim of which was assessment of the technical condition of OLTCs by the acoustic emission method (EA). This method makes the OLTC diagnosis possible without the need of disconnecting a transformer from the system. The measurements were taken in laboratory conditions investigating the influence on the operation non-concurrence of the power tap changer contacts on the AE signals registered. The signals registered were subjected to the analyses in time and time-frequency domains. The result analysis in the time domain was carried out using Hilbert transform and calculating characteristic times for the particular runs. A short-time Fourier transform was used for the assessment of results in the time-frequency domain.

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## **7. Examination on the dependence of acoustic power radiation and the vibration energy flow in rectangular plates**

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The paper presents a comparison of the simulation results of vibrational energy flow in rectangular plates and radiated sound power for steady conditions of force excitation. Analysis was performed for the rectangular plate model, restrained on the edge (clamped end) under the forced harmonic vibration excitation. Under the special interest were the specific cases when the value of the energy flux density in the plate reached the maximum values. To determine the value of sound power, the sound intensity measurements were used in the near field of the plate.

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## **8. Bone ultrasonic scanner**

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Acoustical waves scattered in trabecular bone contain information about its microstructural properties. These properties may change during a disease. Standard ultrasonic examinations of bone (densitometry) are performed in transmission and do not provide complete information

about the bone strength. We have developed the bone ultrasonic scanner that enables measurements of the physical properties of trabecular bone microstructure. Thus the evaluation of bone properties using ultrasonic scanner may be essential for bone diseases diagnosis and treatment monitoring. This study presents application of the scanner, operating at 1.5 MHz frequency, for examination of trabecular bone (calcaneus) in vivo. Backscattered data were collected and processed in order to obtain the power backscattering coefficient (PBSC). The calculated values were compared to those published by several authors in order to verify ultrasonic scanner application as a tool for trabecular bone examination. This study is an approach towards developing a method of investigation of scattering in a trabecular bone, that can potentially provide clinically useful information about bone strength and condition.

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### **9. Microphone array for performance monitoring of ANC systems**

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The paper presents a data acquisition system employing a microphone array, dedicated for measurements of sound pressure-level distribution over an enclosure during an ANC system operation. Acquisition and data processing system were created in order to aid a feed-forward ANC systems design, where one must deal with a serious problem of parameterization of an adaptive control algorithm. In order to solve the crucial problem of proper parameterization of an adaptive feed-forward ANC system, a test and trial approach is required, due to the fact that the shape of spatial zones of quiet enclosures is usually irregular and determined by control algorithm parameters and properties of an electro-acoustical plant. The problem becomes even more complicated when the desired location of spatial zone is time-varying, in such a case, a tool enabling on-line ANC system monitoring is necessary. The data acquisition system presented in the paper enables evaluation of the ANC system performance by providing the following functions: an on-line presentation of pressure level distribution over the enclosure, spectral analysis and estimation of shapes of spatial zones of silence created during the ANC system operation.

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### **10. Issues of data acquisition in noise measurements system with microphone arrays**

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Multichannel data acquisition system is one of the components of noise measurements system with microphone arrays. The article presents a computer program using the PXI platform devices to perform data acquisition. Such matters as synchronization among parts of one device and a possibility of two subsystems placed in a considerable distance working synchronously are discussed.

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### 11. Securing the measurement data in environmental monitoring systems

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Rapid development of the environmental monitoring systems puts increasing demands to data acquisition and transmission subsystems. One of these requirements is to ensure security of the data obtained by the monitoring system during transmission and storage processes. These data are stored in order to build a knowledge base. The article deals with the issues of securing measurement data in environmental monitoring systems. Presented were certain existing cryptographic technologies of data protection, and requirements for cryptographic algorithms were formulated. Selected algorithms and their evaluation for use in noise monitoring systems are discussed.

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### 12. Concept of continuous-discrete middle ear model

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The continuous-discrete model proposed in the paper is developed as the aid for surgical treatment by implementation of ossicles implants. Application of implants always results in changes of the density, distribution and location of centers of ossicle masses. Since dimensions of ossicles are very small, the implemented artificial bones are frequently shorter or longer by a fraction of millimeter than natural bones. The proposed hybrid model of the middle ear consists of a continuous model of the tympanic membrane while the mechanism of ossicles is analytically modeled by methods known from the theory of mechanism analysis. Coupling between the models is obtained by application of the Raigley method of ossicles mechanism mass reduction to the point lying on the umbo. The proposed model has proved to be an efficient tool allowing doctors to predict and design effects of surgical operations and implants design influence on the middle ear acoustical behavior.

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### 13. Influence of support dynamic stiffness on turbojet engine vibrations

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In the paper are presented simple numerical models of the turbojet engine, in which the influence of the system clamping nodes equivalent dynamic stiffness on the system dynamic properties, was taken into account. In the elaborated FEM model, the main dynamic loads

acting on the construction were considered. Special attention was paid to modeling of the contact between compressor shaft and turbine shaft. Dynamic analysis aimed at estimation of the first few natural frequencies of the model and corresponding mode shapes. As a result, the characteristic of changes in the values of system natural frequencies in the function of clamping equivalent dynamic stiffness was obtained.

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#### **14. Ultrasonic investigation of elastic properties of magnetic nanoparticles suspension with PEG biocompatible coating**

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Water suspension of magnetic nanoparticles was analysed by ultrasound spectroscopy. Nanoparticles have a core-shells structure with magnetic core Fe<sub>3</sub>O<sub>4</sub> and surfactant shells. The surface of magnetic particles was coated by oleate sodium as the primary layer and PEG (polyethylene glycol) as the secondary layer. The adiabatic compressibility of nanoparticles and their suspension was calculated from the ultrasonic wave velocity and density measurements. The results show the decrease in the compressibility of magnetic fluid with magnetic particles concentration.

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#### **15. Examination of distribution of speech signal parameters for the prognosis of error probability in speaker verification systems**

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The subject of this work is a text-dependent speaker verification system. A large set of speech recordings obtained from several dozens of speakers has been analyzed. A method based on cepstral speech analysis was used for parameterization. New parameters related to elementary events in speaker recognition process were defined. Using these parameters, an estimate of probability function for these events has been obtained. This allows for using these parameters in the decision system for estimation of the error probability.

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#### **16. Optimization of discriminative procedures in speaker verification process – a method for selecting parameters weights**

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A text-dependent speaker verification system, based on cepstral parameters, was evaluated. Initially, the equal weights were assigned to the parameterization system. Two types of tests

were performed: speaker-speaker and speaker-others. Selection of a vector of weights was based on the full database, using a criterion of minimizing the probability of incorrect decision. The results are presented in a form of confusion matrix. The presented method has been validated using the test part of the database. Correlation analysis of the obtained vectors of weights was also made.

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#### **17. Tissue attenuation estimation from backscattered ultrasound using spatial compounding technique – preliminary results**

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The pathological states of biological tissues are often connected with attenuation changes. Thus, information about attenuating properties of tissue is valuable for the physician and could be useful in ultrasonic diagnosis. We are currently developing a technique for parametric imaging of attenuation and we intend to apply it for *in vivo* characterization of the tissue. The attenuation estimation method, based on the echoes mean frequency changes due to tissue attenuation dispersion is presented. The Doppler IQ technique was adopted to estimate the mean frequency, directly from the raw RF data. The Singular Spectrum Analysis technique was used for the mean frequency trends extraction. These trends were converted into the attenuation distribution and finally, the parametric images were computed. In order to reduce variation of attenuation estimates, the spatial compounding method was applied. Operation and accuracy of the attenuation extracting procedure was verified by calculating the attenuation coefficient distribution, using the data from the tissue phantom with uniform echogenicity but a varying attenuation coefficient (DFS, Denmark).

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#### **18. Dealing with the acoustic field in rooms using the diffusion equation method, based on finite difference method – numerical problems and modifications**

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The room sound field prediction model based on diffusion equation is described. It makes possible to compute the sound field, assuming that sound is a collection of sound particles called phonons. The motion of phonons and their scattering and reflection from the walls is considered as a motion, scattering and reflection of fluid particles. The model allows for prediction of the acoustic field in complex-shaped rooms, with diverse absorption coefficient. Diffusion sound field model is developed on the basis of two hypotheses. The sound field is uniform and sound energy flow is the same in all directions. The diffusion-based model allows to analyze the steady-state as well as time-varying sound fields, which makes it a useful tool in room acoustics. This article takes into account the method of numerical implementation of diffusion equation in acoustics, shows some numerical problems which can appear during calculation of energy density using



the finite difference method and describes the diffusion equation modifications, which deal with numerical problems.

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### **19. Numerical modeling of the heating area and heat sources intensities in rat liver *in vivo*, due to the concentrated ultrasound beam of low intensity**

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Modeling of the hyperthermia, procedure of raising the temperature above 37°C, as a treatment modality is considered. Low intensity, concentrated ultrasound beam was already used as a source of temperature rise in tissue liver in experiments performed *in vitro*. The circular, focused ultrasonic transducer with a diameter of 15 [mm], focal length of 25 [mm] and resonance frequency of 2 [MHz], has been used to generate the pulsed ultrasonic beam. The temperature rise, measured by thermocouples, were already compared with one of our Finite Element Method models. Now, we propose a new FEM model for obtaining an appropriate heating scheme *in vivo* of the rat liver tissue. At first, the existence of blood perfusion is taken into account in the modeling equations. Secondly, the thermal and acoustic properties, being the input parameters to the numerical model, are taken from the published data in literature, while the size and intensity of heat sources are modeled in agreement with the results obtained from solutions of nonlinear equation of acoustic wave propagation in 3-layer attenuating medium. We demonstrate that the results of numerical model of heating process *in vivo* strongly depends on the density of heat power, as well as on the size of the heated domain. Two special numerical approximations of heat sources are considered. The first case concerns the homogeneous distribution of heat power density in the area of 3 concentrated cylinders imitating the size of the acoustic beam. The second case concerns the non-homogeneous distribution of power density, obtained directly from numerical solutions by Padé approximations of finite order. The results are compared and discussed. The influence of different models on temperature rise profiles are demonstrated.

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### **20. Influence of change of mandrel diameter of helicoidal resonator on its acoustic attenuation performance**

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This work presents the influence of change of mandrel diameter of helicoidal resonator on its acoustic attenuation performance. Sets of numerically computed systems with different mandrel diameters were executed.

For numerical investigations, by the use of a finite element method, the helicoidal resonator is placed inside an infinitely long cylindrical duct. Also the transmission loss is achieved as an acoustic attenuation performance parameter. It is shown that the mandrel is a very important part of the helicoidal resonator and it provides a proper work of this solution, as an acoustic

resonator. Also this paper presents the normalized range of mandrel diameters, which give the best acoustic attenuation performance.

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## 21. Two-channel active earplugs with simplified noise source localization

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Classical personal hearing protectors may sometimes not satisfy industrial internal working place requirements. The authors promote active earplugs to avoid such problems. Fixed parameter approach to control is appreciated to avoid transient effects occurring in adaptive systems. The idea of generalized disturbance in order to respond to noise nonstationarity, has been put forward by the authors. Active feedforward noise control is mostly effective when a reference signal is acquired in advance. However, when the user's head turns with respect to the noise source, such a condition can be violated. After identifying the head rotation with respect to the noise source, the best control filter for the actual position could be selected. Moreover, active reduction for each ear could be further improved by using reference signals acquired by microphones at both ears, and including direct and cross-filters. The aim of this paper is to develop and verify such an approach. Simulation experiments are conducted, based on real world measurements performed using the active earplugs, G.R.A.S. artificial head, and the noise recorded in a power plant.

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## 22. The joint vibration analysis of a multi-link surgical manipulator with an antiseptic coating

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This paper presents a synthesis of the mathematical model of a multi-link surgical micro-manipulator joint. The manipulators' prototype contains 6 links with a diameter of 8–10 [mm] and with the length of the modules of about 130 [mm]. It is driven by brushless servomotors with worm and planetary gears, for which the total transmission ratio is above 1/10000. The essential feature of manipulator in question is an antiseptic coating which covers the whole construction. Because of the complicated form of the drive model and the external coating interactions, the control of such a system is significantly different from a typical industrial robot control. Regarding low efficiency of micro-robots drive systems, a reliable joint model is crucial to the development of a high-precision control system and to the selection of appropriate parameters identification method. To achieve the required accuracy, modelling framework has been enriched with coating interactions and advanced model of friction. Simulation results are presented and discussed.

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### 23. Scattering model of trabecular bone

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In our previous study we have developed the simulation technique that enables determination of the ultrasound signal received at the pulse-echo transducer surface after interrogation of cancellous bone. The simulation can be applied for different scattering models of a trabecular structure. In this study we examined newly developed scattering models of the trabecular bone for their abilities to mimic the frequency dependent backscattering coefficient measured in the cancellous bone. Three types of trabeculae mimicking scatterers were considered. First, the bone consisted of cylinders with varying thickness (Gamma distributed) within the population, was assumed. The next two cases accounted for the contribution of thick and thin trabeculae to the total backscattered signal. The second model assumed existence of two populations of the cylindrical scatterers, significantly differing in the average value of Gamma distributed diameters. Finally, the mixed model composed of thick and thin trabeculae, modeled respectively by cylindrical and spherical scatterers, was examined. The last selection resulted from the similarity found between scattering on small sphere and finite cylinder. Calculated echoes demonstrated the usefulness of the mixed model. Frequency dependence of backscattering coefficient agreed well with the experimentally determined dependences.

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### 24. Adaptive active noise control of sound transmitted through a plate with insufficient acoustic isolation

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Reducing acoustic pressure level of sound transmitted through a plate is of great scientific interest because of a number of potential applications. It is known that simply reducing vibration of the plate is not an efficient way for that purpose, particularly if the sound also leaks by some other paths due to insufficient isolation. Sound pressures at different points in space are rather measured and reduced then. They are considered as error signals, used for updating parameters of adaptive filters. This paper presents an adaptive multichannel Filtered Reference LMS-based algorithm for active control of noise, transmitted through a clamped rectangular thin aluminum plate with insufficient acoustic isolation. The proposed cost function to be minimized combines sound pressures at a reduced number of specified points and plate vibration measurements. The plate is excited with multiple Macro-Fiber Composite actuators.

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## **25. Application of online secondary path estimation for ANC system with moving error microphone: simulation results**

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In the paper, adaptive active noise control (ANC) systems creating quiet zones around a microphone moving in an enclosure, are revised. They use LMS-based adaptive control algorithm, parameterised with a model of a secondary path. The change of the microphone position during the system operation causes secondary path modeling errors, which, in some cases, can be coped by an adaptive control algorithm itself, or an on-line estimation routine has to be employed to update the secondary path model.

The problem of parameterisation of ANC systems with moving error microphone and on-line estimation of a secondary path model, is presented and illustrated with simulation results. Attenuation of the random disturbance is improved after application of on-line estimation of the secondary path model, in comparison to the case of an adaptive ANC system using a constant secondary path model. The proper parameterisation of the on-line secondary path estimation routine assures convergence of the control algorithm; however, the choice of three-step sizes for three LMS algorithms is a challenge.

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## **26. Identification and classification of dangerous and particularly important places (with the exception of pedestrian crossings) for visually impaired people in urban agglomerations**

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The paper presents results of questionnaires concerning identification and classification of dangerous and particularly important places for blind and visually impaired people in large urban agglomerations were presented. This is the first part of the developmental project, which aims at creating a system that would help visually impaired people in spatial orientation. In the presented results pedestrians crossing are excluded, because of their own specific regulations. Respondents were to show situations that are most stressful and troublesome for them. Also the data concerning things that are helping or hampering the motion in urban environment for visually impaired people were collected. This study is mostly focused on acoustical events, because sounds (with touch) coming to blind and visually impaired people are crucial information about the surroundings.

Results of this surveys are the basis for governing latter phases of the project. The projects as a whole aims at creating of a vibration-touch system, helpful in urban spatial orientation.

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**27. An analysis of selected problems of simultaneous transmission of a light wave and an ultrasonic wave via flexible optical fiber**

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The active applications of ultrasounds and lasers in surgery have a similar aim. Both technologies complement each other and therefore, what happens very often during a medical procedure, is the simultaneous use of these two methods from separate standard devices. The possibility of acoustic wave propagation in optical waveguides creates new prospects for simultaneous transmission of laser beam and ultrasonic wave. Such combined laser-ultrasonic system could be useful e.g. during surgical treatment. The combination of laser and ultrasounds in one device could have many advantages. The article presents the results of experimental studies of transmission of ultrasonic wave in optical fibres, and analysis of possibilities of simultaneous transmission of a light wave and an ultrasonic wave in optical fiber.

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**28. Transmission of ultrasonic waves in an optical fibre doped by 7.5% of TiO<sub>2</sub> using a sandwich-type transducer**

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The possibility of acoustic wave propagation in optical waveguides creates new prospects for simultaneous transmission of laser beams and ultrasonic waves. Combined laser-ultrasonic technology could be useful in e.g. surgical treatment.

The article presents the results of experimental studies of transmission of ultrasonic waves in optical fibres, the core of which is doped by 7.5 % of TiO<sub>2</sub>, using a sandwich type transducer. It also presents amplitude characteristics of an ultrasonic signal propagated in the optical fibre. The authors studied the effect, the length of the fibre has on the achieved output signal amplitudes. They presented the relation of the output signal amplitude from a capacitive sensor to the power, applied to the sandwich-type transducer. The obtained results were compared with results produced when using an optical fibre with a core doped by 3% of GeO<sub>2</sub>, in order to select the optical fibre suitable for simultaneous transmission of ultrasonic waves and laser rays.

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**29. An attempt to determine impact of a room shape on the reverberation time**

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One of the most important parameters defining acoustics of the interior is time of reverberation which determines all other parameters defining e.g. the quality of speech, articulation,

clarity of music, basses ratio, warmth of sound, etc. The authors of the paper made an attempt to determine the impact of a room shape, length to height ratio on the reverberation time. After first simulations and studies it seems that not only the room acoustic absorption and capacity influences reverberation time but also the room shape.

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### **30. Characterization of human skin using statistics of backscattered signal envelope**

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The scattering of ultrasonic waves depends on the size, shape, acoustical properties and concentration of scatterers in the tissue. In these study the statistics of envelope of signal was used to assess the structural properties of the skin tissue. Ultrasound backscatter data were obtained from healthy and pathological human dermis *in vivo*. The signal envelope statistics were examined by fitting the Rayleigh and K distributions. The fit between the K distribution and the data shows much smaller error than the Rayleigh model. The parameter of the K-distribution, namely the effective number of scatterers, was calculated and the potential of the effective number of scatterers to distinguish between normal and disease tissues was investigated. The obtained results indicate that the parameter of the K-distribution may be useful in classification of the skin lesions.

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### **31. The effect of removal of local noise masker on the perception of time envelope in short sounds**

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Sounds of musical instruments interact in the hearing process in a complex way, including local masking of their particular components. Energetic masking of an element of a sound in a limited region of the time-frequency plane has been investigated. A universal model of sound attack was generated with the use of noise. The model was masked alternatively: with broadband noise and with the same noise without a spectro-temporal region, coinciding with the model. The ability of listeners to recognise the length of the attack in the two stimuli was compared. There was no difference in the total number of recognitions in both stimuli, but the slope of the psychometric function presenting the relationship between the percentage of recognitions and the attack's length differed considerably.

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### 32. Application of acoustic emission in food properties testing

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In the paper, a history of food properties testing by acoustic methods was presented. The contact and contactless method of receiving acoustic signal including technical equipment description was compared. A variety of applied signal descriptors used for analyzing experimental results was listed. Some examples of experimental results of examination of bread and snack-type food was added.

\* \* \*

### 33. Environmental noise measuring system with microphone matrices

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Measuring system for noise sources identification in complex acoustical situations has been presented. The system consists of one or two microphone matrices and the 64-channel equipment for signal acquisition and processing with the memory for the measured data. The system is equipped in video camera and GPS station. The system can work either as the 64-channels controlled by mobile computer or as two subsystems with the wireless synchronization, each of them controlled by his own mobile computer.

\* \* \*

### 34. Annular array transducer and matched amplifier for therapeutic ultrasound

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The use of therapeutic ultrasound continues to grow. The focused ultrasonic wave can increase the tissue temperature locally for the non-invasive cancer treatment or other medical applications. Authors have designed the seven-element circular array transducer operating at 2.4 MHz. Each element was excited by sine burst supplied by a linear amplifier and FPGA control circuits. Acoustic field, generated by transducer was simulated in a computer and compared to water tank hydrophone measurements. They were performed at 20, 40 and 60 mm focal points. The results showed good agreement between the measurements and theory and possibility to focus the ultrasound in the previously selected area. The transducer has delivered 2.4 W of acoustic power, sufficient for the ultrasonic therapy.

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### **35. Preliminary results: analysis of Synthetic Transmit Aperture technique in ultrasonic imaging**

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The Synthetic Aperture (SA) methods are widespread and successfully used in radar technology, as well as in the sonar systems. The advantages of relatively good resolution in the whole area of scanning without decrease of frame rate, make this technique an object of interest in medical imaging methods, such as ultrasonography (US). This paper describes the possible usage of the SA method in ultrasound imaging. The measurements of different SA schemes were conducted using the set-up consisting of the research ultrasonograph module, the PC and the special wire phantom. The results for different schemes of image reconstruction are presented. Particularly the Synthetic Transmit Aperture (STA) technique was concerned. Results of the STA method are discussed in this paper.

\* \* \*

### **36. Statistical correlation method in measurement of psychoacoustic observations. Theoretical basics and prospects of application in psychoacoustics and musical acoustics**

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The purpose of this article is to present general assumptions concerning an alternative method of scaling the auditory perception features, considered to be typically quantitative. This method is expected to scale also such features of auditory perception scaling of which is out of range within the previously applied classical methods that in turn is necessary to create a coherent mathematical model describing auditory perception generated by sounds of music in the broad sense, with their time sequence taken into account. Examples of perception phenomena that could be considered within the framework of the presented model are: the tonality (understood as the feature organizing sounds on the scale from noise up to a sound of single pitch); the consolidation level of different sounds perceived simultaneously; the level of affinity between different sounds; the quantitative arrangement on the dissonance-consonance scale; and many other complex perceptual phenomena. The aim of the research is to develop the presented method of psychoacoustical measurements and to deliver new tools, necessary for quantitative auditory perception analysis as well as to improve mathematical modelling of the auditory system.

\* \* \*

### **37. Sound field radiated from an un baffled lined cylindrical duct in case of axisymmetric excitation**

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The paper presents a method of approximate derivation of the acoustic pressure directivity characteristics of the sound field, radiated from the outlet of a lined un baffled cylindrical duct



by means of some modifications of the directivity functions calculated for equivalent hard duct. The results are obtained by considering diffraction at one duct end, meaning mathematically that the semi-infinite duct is considered. As the boundary condition is imposed on a semi-infinite cylinder, the solution of the wave equation for the velocity potential (or acoustic pressure) can be obtained by means of the Wiener-Hopf factorization method. In the far field the velocity potential, represented by a contour integral, can be transformed into the form of spherical wave multiplied by the directivity function. The consecutive steps of solving the problem for hard (infinite impedance of the wall), soft (zero impedance wall) or lined (complex impedance) duct are analogous. However, assumption of the complex wall impedance results in occurrence of complex roots of the boundary condition in solution of the wave equation, substantially influencing the nature of admissible duct modes. For both duct types – hard and soft – roots of the boundary conditions are real what imposes a strict condition,  $k = \beta$ , ( $k$  – free-space wave number,  $\beta$  – radial wave number), distinguishing propagating modes,  $k > \beta$ , from exponentially attenuated  $k < \beta$  ones. In case of a lined duct, all modes are partly attenuated and therefore a necessity arises to formulate analogous condition, distinguishing slightly the attenuated modes from those highly attenuated. Such a condition allows in turn to limit the considerations only to the modes propagating without attenuation and to generalize the previously obtained formulae for the hard duct onto the lined one. The formulae are derived for radial and circumferential modes.

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### 38. Full-wave analysis of finite baffle system for linear phased array applications

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Mixed boundary-value problem for a finite system of rigid baffles in acoustic medium is solved for the case of sound radiation, with the help of the method developed earlier in electrostatics. The solution is sought in spectral domain. The method described here enables direct evaluation of the spatial spectrum of pressure distribution on the baffle plane, which is used for the far-field radiation pattern evaluation. The approach can be used for the phased array modelling with the finite element size and the inter-element interactions taken into account. Some illustrative numerical examples present the far-field radiation pattern and the wave-beam steering in a baffle system that may be considered as a model of one-dimensional ultrasonic transducer array.

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### 39. Element directivity influence in the synthetic focusing algorithm for ultrasound imaging

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The paper describes the modified synthetic focusing (SF) algorithm for ultrasound imaging. Synthetic focusing method, being a particular case of the synthetic aperture (SA) technique, is an alternate to a conventional phased array. At each time one array element transmits an ultrasound pulse and all the elements receive the echo signals. The modification discussed here

concerns a directivity property of array element which becomes significant as the element width becomes comparable to the wavelength corresponding to the nominal frequency of transmit signal. The angular dependence of the radiation efficiency of array element is approximated by a far-field radiation pattern of a single narrow strip transducer, excited by a time harmonic uniform pressure distribution over its width. The corresponding function is calculated at the nominal frequency of excitation signal and is incorporated into the conventional SF imaging algorithm. The comparison of the modified and conventional SF algorithms by means of numerical experiments performed with the help of FIELD II simulation program for MATLAB environment, reveals significant improvement of the image quality in the region close to the aperture as well as increase in the imaging depth.

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#### **40. Multielement synthetic transmit aperture in medical ultrasound imaging**

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Synthetic aperture (SA) technique is a novel approach to today's commercial systems and has previously not been used in medical ultrasound imaging. The basic idea of SA is to combine the information acquired simultaneously from all directions over a number of emissions and to reconstruct the full image from these data.

The paper describes the multielement STA method in medical ultrasound imaging with a small number of elements transmitting and all elements receiving apertures. Compared to other methods, the multielement STA allows to increase the system frame rate and provides the best compromise between penetration depth and lateral resolution. In the experiments, a 32-element linear transducer array with 0.48 mm inter-element spacing and a burst pulse of 100 ns duration were used. Two elements wide transmission aperture was used to generate an ultrasound wave covering the full image region. The comparison of 2D ultrasound images of tissue mimicking phantom obtained using STA and multielement STA methods, are presented to demonstrate the benefits of the second method.

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#### **41. Implementation of selected wall filter in FPGA for multi-gate transcranial Doppler system**

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The article describes selection and implementation of the wall filter in field programmable logical array (FPGA), for the multi-gate transcranial system of blood flowmeter developed in the Ultrasound Department of IPPT PAN. The purpose of the implementation of the filters in FPGA was a reduction of software processing of Doppler signals. The work presents model simulation and comparison of the wall filters with finite impulse response (FIR) as well as infinite impulse response (IIR). The range of stable work of the IIR filter was analyzed. The effect of

the filter type on quality of correlative estimation of average frequency was evaluated. Then the selected high-pass FIR filter was implemented and optimized to the architecture of the FPGA and the application in the flowmeter. The economical FPGA system – Altera Cyclone III EP3C25F324C8 – was applied. The developed wall filter realizes 100 parallel high-pass FIR filters what provides simultaneous filtering of Doppler signal in 100 gates. The filters operate on 16 bites samples of signal, whereas their characteristic is programmable by the number of 65 16-bites coefficients. The realization was verified on Altera Quartus II 9.1 and Model Sim 6.5b software by simulations and comparison of impulse and step responses of the filter. As a result, the implementation of the wall filter in Cyclone III FPGA system uses 5% of its logical resources and 34% of its memory resources.

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#### **42. Modeling of ultrasound transmission in electro insulation oil**

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A verification study of ultrasound transmission simulation results with experiment results is presented in this paper. The work considers a model of a power transformer tank which is filled with insulating oil. In the experiment, an ultrasound wave is generated by a piezoelectric transducer that is fixed in the center of the tank and measured by another transducer, also mounted inside the tank. The transducer generates AE wave in ultrasound frequency band up to 1 MHz. The simulation considers numerical calculation of acoustic pressure distribution inside the model. A verification result of the numerically calculated values with measurements, performed under laboratory conditions, is presented in the paper.

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#### **43. Analysis of changes in the frequency spectrum of acoustic emission signals in transformer oil**

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Analysis results of frequency spectrum of acoustic emission (AE) signal, propagating in a transformer tank filled with insulating oil, are presented in the paper. The acoustic emission signal was generated by a piezoelectric transducer which was fixed in the center of the tank. Another transducer was placed at distances: 10, 20 and 30 cm from the source and was measuring the AE signal. Frequencies from 1 kHz to 1 MHz with step of 1 kHz have been examined. Gathered data were analyzed in the frequency and time-frequency domains. Further, the PSD and the MUSIC pseudospectrums have been calculated. Presented results depict that independently of the (considered) distance between source and sink, for high frequency signals the measured signal amplitude is not much smaller than for low frequency signals; however, it can be stated that the transformer oil attenuates high-frequency AE signals more than low-frequency AE signals.

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#### 44. Automatic detection of audible corona noise from power lines

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One of the most difficult tasks in the system of continuous monitoring is automatic detection and classification of acoustic events. A possible solution is to use the pattern recognition techniques for acoustic signal recorded by a monitoring station.

Monitoring measurements have been carried out around 400 kV line in the double circuit system with triple sub-conductors bundle  $3 \times 350 \text{ mm}^2$ . To identify the corona acoustic signal, the spectrum in 1/3 octave bands in range from 20 Hz to 20 kHz and A-weighted sound pressure level have been recorded (with 10 sec buffer step), and statistical spectrum (averaged every 15 min). Recorded parameters have been used to identify the distinctive features of the corona acoustic signal, which are normalized spectral moments of 0, 1 and 2 order ( $M_0$ ,  $M_1$ ,  $M_2$ ), the power factors of the spectra split for tonal band from 20 to 400 Hz ( $PC_1$ ) and noise band from 1000 to 10 000 Hz ( $PC_2$ ). The next parameters are related to the detection of the presence of tonal components (100 and 200 Hz) in the recorded spectra ( $TC_{100}$ ,  $TC_{200}$ ). In an experimental research, optimal artificial neural network has been chosen which allows classification of samples from the presented monitoring station database.

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#### 45. Modeling the distribution of long-term noise levels in vicinity of high voltage power lines

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To overcome the conditions imposed on investors' new power lines in range of environmental protection and increase of the capacity of the existing lines, new lines are designed or modernized for multi-circuit and multi-voltage ones, the environmental impact of which is limited within the present land of use technical belt.

The existing acoustic models of AC transmission lines are mostly empirical and their applications are limited to calculations of corona noise levels, generated by the line in the worst situations, i.e. in heavy rain, what is necessary for the line designers. However for evaluation of the long-term noise levels generated by the line, it is necessary to know also the noise generated by the line in fair weather.

The paper shows a model to calculate the sound power level of unit length phase conductors as a function of rainfall intensity and the technical condition of the conductors for any geometric arrangement. Calculation of the distribution of long-term noise indicators was performed in diverse terrain considerations.

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