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The International Symposium on the Mathematical Theory of Networks and Systems, St. Louis, Missouri, USA, June 24-28, 1996

## Study on Controllability and Observability of Linear System with Structured Uncertainty

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This presentation is concerned with the controllability and observability of interval system, where the system matrix is expressed in polynomial form of interval parameters in the state space expression of the system. In our previous work, we have extended the mapping theorem to the general case where parameters appear nonlinearly via the monotonicity test. In this paper, we apply this monotonocity test to the study of the controllability and the observability test of SISO and MIMO linear systems with structured uncertainties. For one parameter case, we derive the necessary and sufficient conditions of controllability and observability. For multi-parameter case, defining the monotonicity of multivariable function and using our monotonicity tests for interval polynomials, we give sufficient conditions of controllability and observability of the system.

1995 IEEE IAS Annual Conference October 8-12, Orlando. FL U. S. A.

## Harmonic Evaluation of an NPC PWM Inverter Employing the Harmonic Distortion Determining Factor

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Y. IWAJI
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This paer describes a new harmonic evaluation scheme for neutral-point-clamped (NPC) inverters employing the harmonic distortion determining factor (HDDF). HDDF represents a harmonic component of inverter output current norwalized by the device switching frequeucy when the inverter load is inductive. HDDF curves under variable voltage conditions are illus-

trated for typical three NPC PWM strategies, unipolar PWM, double carrier unipolar PWM and double carrier dipolar PWM, and the evaluation of these PWM patterns based on the HDDF values are given. The accuracy of the harmonic component in the motor current estimated by use of HDDF values is discussed comparing the ones obtained by the time domain simulation.

The International Conf. of Electrical Eng., Taejon, Korea, July 19-21, 1995

## Operation of Reactive Power Suppliers Using a Genetic Algorithm

S. K. LEE*, J. K. PARK*, H. KITA and J. HASEGAWA
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Due to limited transmission capabilities and the difficulty in finding new places for power supplier to accomodate additional loads, reactive power allocation and utilization have received increasing attention in recent years. One method to overcome these problems is adequate utilization of the reactive power supplier (RPS) equipment which is installed in the system. However, the utilization of the RPS equipment is difficult, as RPS equipment is of the discrete type and the system is nonlinear. This paper used the successive iterative method between the genetic algorithm (GA) and Newton-Raphson method to solve the nonlinear combinatorial integer problem. The proposed method was applied to the IEEE 30 bus 6 generator system to prove its validity and effectiveness.

The International Conf. of Electrical Eng., Taejon, Korea, July 19-21, 1995

## A Study of the Introduction Evaluation of Dispersed Energy Strage Systems in Distribution Systems — Based on Secondary Battery —

D. RHO, H. KITA, K. NISHIYA* and J. HASEGAWA
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Recently, the operation of electric power system has become more difficult because the peak load demand in increasing continuously and also the daily load factor is worsening. Furthermore, global environmental issues are required in electric power systems. One countermeasure to overcome these problems is a study on the operation methods of a new electric

power system that includes dispersed Energy Storage (DES) systems. This paper deals with the introduction evaluation methods on the DES systems. Because the DES systems are costly, it is important that their introduction evaluation is performed in a synthetical and quantitative fashion. The direct and indirect benefits of DES systems are classified and analyzed on the utility side for cases where DES systems are introduced to distribution systems. Further, the multiple functions of DES systems such as load leveling and effective utilization of distribution facilities are evaluated by quantitative methods, which are the successive approximation solution considering both the optimal generation mix and the optimal operation of DES systems, and present worth analysis, respectively.

The International Conf. of Electrical Eng., Taejon, Korea, July 19-21, 1995

## Energy Analysis and $CO_2$ Analysis of Superconducting Magnetic Energy Strage Systems

S. KAMIYA, E. TANAKA and J. HASEGAWA
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Evaluations of power plants, such as thermal plants and nuclear plants, have been carried out mainly from an economical viewpoint. However, because of environmental deterioration, it is necessary to carry out the energy analysis (EA) and greenhouse effect analysis. The evaluation of superconducting magnetic energy storage (SMES) has also been carried out from an economical viewpoint. This paper tries to perform the EA and greenhouse effect analysis of SMES. Two types of evaluation are carried out:

1. Comparison of SMES with ordinary power plants.

By assuming that the saved energy input by introducing SMES is equal to the required energy for storage, we can neglect charging energy for SMES. As a result, SMES can be treated like renewable energy power plants.

2. Evaluation of SMES in a power system.

The EA of a power system with and without SMES are performed under ordinary economical operation.

IEE Japan Power & Energy '95, the Sixth Annual Conf. of Power & Energy Society IEE Japan, Session I-E, Nagoya, Japan, August 2-4, 1995

## Minimum Loss Load Flow Calculation Using Genetic Algorithm

S. K. LEE*, J. K. PARK*, H. KITA and J. HASEGAWA
Department of Electrical Engineering, Hokkaido University, Japan
*Seoul National University, Seoul, Korea

This paper presents an optimal load flow method for minimizing real power loss using a genetic algorithm. The basic process is the same as the Gauss-Seidel method. A genetic algorithm is introduced into the Gauss-Seidel method to find the optimal power flow because the Gauss-Seidel method calculates all the variable one by one and is easy to apply. However, the Gauss-Seidel method has the following defects:

1) It has slow convergence characteristics.
2) It falls into a local minimum.

By using the genetic algorithm, these defects have been cleared. The Genetic Algorithm is worth the price for searching the minimum value of a specified objective function. The genetic algorithm can reach a minimum value of a specified objective through generations. However, in certain conditions, it does not converge to the global minimum but to the local minimum. To solve this problem, a pyramid population is proposed and introduced to the optimal load flow calculation.

IEE Japan Power & Energy '95, the Sixth Annual Conf. of Power & Energy Society IEE Japan, Session I-E, Nagoya, Japan, August 2-4, 1995

## The Application of Fuzzy Dynamic Programming to the Optimal Generation Mix Problem

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The optimal generation mix problem is carried out in order to decide the type, amount and timing of technology purchases. Many techniques have been developed for solving the genera-

tion mix problem, however, the problem of dealing with elements of uncertainty has not always been well addressed. The solutions are generally of a deterministic nature and do not provide a flexible generation mix solution that considers various scenarios. In this paper, the authors present a fuzzy dynamic programming approach that uses fuzzy membership functions to express cost fluctuations and uses the concept of applying various load duration curve scenario to represent the uncertainty of future load demand trend, resulting in an optimal, robust flexible generation mix solution. In addition, a decision making process previously developed by the authors, referred to as the dominant relation technique, is again utilized to assess the suitability of each feasible path.

1995 International Conf. Energy Management and Power Delivery, EMPD'95
Singapore, Nov. 21-23, 1995

## An Advanced Flexible and Reliable Distribution Systems

K. NARA* and J. HASEGAWA
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*Ibaraki University, Hitachi, 316, Japan

In this paper, the authors propose a new concept of electric power distribution system named "Flexible, Reliable, Intelligent and Energy coNservative Distribution System (FRIENDS)". In the near future, electric power systems will be facilitated by dispersed energy resources and dispersed energy storages on the demand side. The electrical power distribution system itself will have to be changed to cope with these facilities. The authors propose a flexible power distribution system for such a situation. Noticeable characteristics for the proposed system (FRIENDS) are flexible network reconfiguration for uninterrupted power supply through power electronics devices, new protective relaying schemes, on-line information service to customers (including automated metering), DSM and home automation as well as multi-quality power supply. In this paper, the new concept of the power distribution system of FRIENDS is explained, and how the new functions can be realized is discussed.

1995 International Conf. Energy Management and Power Delivery, EMPD'95 Singapore, Nov. 21-23, 1995

## A Study on the Optimal Voltage Regulation Methods in Power Distribution Systems Interconnected with Dispersed Energy Storage and Generation Systems

D. RHO, H. KITA, K. NISHIYA* and J. HASEGAWA
Department of Electrical Engineering, Hokkaido University, Japan
*Hokkaido Institute of Technology, Sapporo, 006, Japan

With the developement of industry and the improvement of living standards, better quality in power electric service is required more than ever before. Also, as one of the countermeasures against daily load factors worsening and global environmental issues, DSG systems such as photovoltaic cells, fuel cells and secondary battery storage, are being interconnected with power distribution systems. Under these circumstances, to deliver reasonable voltages to as many customers as possible, optimal voltage regulation methods in distribution systems need to be developed.

In this paper, optimal voltage regulation methods based on the statistical analysis considering customer voltage conditions and operation characteristics of DSG systems are presented. To avoid errors in the computation process, customer voltages are converted into one voltage value and simplified. Optimal coordination methods of multiple voltage regulators are also suggested by the quasi-Newton iteration method. In addition, the introduction impacts of DSG systems related to optimal relation sites and the introduction capacity of DSG systems are evaluated by a performance index expresses by customer voltage conditions.

Inter. Conf. on Intelligent Systems Applications to Power Systems (ISAP'96) Orlando, USA, Jan. 28-Feb. 2, 1996

## Future Flexible Power Delivery System and Its Intelligent Functions

K. NARA* and J. HASEGAWA
Department of Electrical Engineering, Hokkaido University, Japan
*Ibaraki University, Hitachi, 316, Japan

In this paper, the authors propose a "Flexible, Reliable, Intelligent and Energy coNservative Distribution System (FRIENDS)" and discuss its intelligent functions. In the near future,

electric power systems will be facilitated by dispersed energy resources and dispersed energy storages on the demand side. The electrical power distribution system itself will have to be changed to co-operate with these facilities. The authors have proposed a flexible system named FRIENDS for such a situation. Noticeable intelligent functions for FRIENDS are flexible network reconfiguration for uninterrupted power supply, protective control, on-line information service to customers (including automated metering), DSM and home automation as well as multi-quality power supply. In this paper, the new concept of the power delivery system of FRIENDS is explained, and how the intelligent functions can be realized in it is discussed.

The Third Japanese-Czech-Slovak Joint Seminar on APPLIED ELECTRO-MAGNETICS, July 5-7, 1995, Prague, Czech Republic

## Precise Charged Particle Trajectory Caluculation Using Lie Ring

Hideki KAWAGUCHI and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

This paper presents a precise integrator for charged particle motion based on the covariant form equation of motion. It is shown that use of the covariant form enable us to construct " explicit " scheme precise integrator, which results in high speed calculation. Concrete numerical simulation results show us that this integrator indeed provides the precise and high speed calculations.

10th Conference on the Computation of Electromagnetic Fields July 10-13, 1995, Berlin, Germany

## Consideration on Numerical Instability of Dirichlet Gauge BEM

Hideki KAWAGUCHI and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

Authors have been discussing numerical simulation methods of transient electromagnetic fields based on scalar and vector potentials and have shown that the Dirichlet type boundary condition can be applied for the potentials and the conditions are quite convenient for numerical simulations based on the boundary element method (BEM). Then, numerical instability conditions are the most important things for such the time dependent problems. From this point of view, this paper discusses numerical instabilities of the boundary element analysis of

transient electromagnetic fields using the potentials and presents the stability condition.

10th Conference on the Computation of Electromagnetic Fields July 10-13, 1995, Berlin, Germany

## A Boundary Element Analysis of Transmission-line Parameters Using Singular Elements

Hajime IGARASHI, Yoshio MIZUYAMA and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

This paper presents a boundary element analysis of transmission-line parameters on the basis of the quasi-TEM assumption. Singular boundary elements are employed to model the corner singularities at sharp conductor edges. The boundary integrals consisting of the free space Green function and singular interpolation functions are regularized by a Taylor expansion technique, and are then evaluated using the standard Gaussian quadrature. The numerical results for a simple test problem show the reliability of the present method.

10th Conference on the Computation of Electromagnetic Fields July 10-13, 1995, Berlin, Germany

## An Analysis of Thin Magnetic Materials Using Hypersingular Integral Equations

Hajime IGARASHI and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

This paper describes a two-dimensional analysis of magnetic fields with thin magnetic materials using hypersingular integral equations. In this analysis, the thin materials are modeled as infinitesimally thin sheets, on which hypersingular integral equations for the vector potential are formulated. The hypersingular integral equation is discretized by boundary element method, on the basis of the Hadamard finite part integral, to numerically compute magnetic fields. The present method is shown to give an accurate magnetic field in a cylindrical magnetic shell with linear permeability. Moreover, numerical results for the shell with nonlinear permeability are provided.

10th Conference on the Computation of Electromagnetic Fields July 10-13, 1995, Berlin, Germany

## Numerical analysis of magnetization of a bulk High Tc superconductor

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Y. ITOH, Y. YANAGI, M. YOSHIKAWA and T. OKA
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Y. YAMADA and U. MIZUTANI
Dept. of Crystalline Materials Science, Nagoya University, Japan

Magnetization process of a bulk high Tc superconductor (HTSC) is evaluated with a numerical simulation code. Field-cooled magnetizations of the HTSC is analyzed with the critical state model. The pulse magnetization process is also analyzed with the flux creep-flow model. The numerical solutions are discussed to clarify the time depending effects in the reported experimental results on the pulse magnetization.

2nd Japan-Korea Joint Symp. on Electrical Engineering, July 19-21, 1995, Teajon, Korea

## A Boundary Element Analysis of Transmission lines Considering Corner Singularities

Yoshio MIZUYAMA, Hajime IGARASHI and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

This paper presents a boundary element analysis of transmission lines considering corner singularities under the quasi-TEM assumption. In the analysis, singular boundary elements are employed to express the corner singularities at sharp conductor edges. The boundary integrals consisting of the Green function and singular interpolation functions are regularized by a Taylor expansion technique, and are then evaluated using the standard Gaussian quadrature. The present method is applied to the analysis of test problems with multiconductor lines in multilayered dielectric substrates, to show its performance.

2nd Japan-Korea Joint Symp. on Electrical Engineering, July 19-21, 1995, Teajon, Korea

## Dependence of Bootstrap Currents on the Aspect Ratio

Y. MOROBOSHI, H. IGARASHI, S. TOKUDA* and T. HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan
*Japan Atomic Energy Research Institute, Ibaraki, Japan

This paper describes a numerical analysis of dependence of bootstrap currents on the aspect ratio of a toroidal plasma for nuclear fusion. In this analysis, the Grad-Shafranov equation, which describes the equilibrium of magnetohydrodynamic plasmas, is numerically solved under the condition that the total amount of the plasma current is kept constant. It is revealed that the decrease in the aspect ratio increases the fraction of the bootstrap current because of the mirror effect.

2nd Japan-Korea Joint Symp. on Electrical Engineering, July 19-21, 1995, Teajon, Korea

## Finite Element Analysis of the Helmholtz Equation with Field Singularities

Atsushi MINATO, Hajime IGARASHI, Hideki KAWAGUCHI and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

This paper describes a finite element method for the accurate solution of the Helmholtz equation with field singuralities. It is known that the spatial derivatives of an unknown function in the Helmholtz equation become infinite at sharp metal edges. These singularities deteriorate the accuracy of the finite element solutions. In this paper, a regularized unknown function is introduced by subtracting off the field singularities to improve the accuracy and convergence of finite element solutions. The numerical results for two test problems show that the present method clearly improves the accuracy of the solutions.

2nd Japan-Korea Joint Symp. on Electrical Engineering, July 19-21, 1995, Teajon, Korea

## Consideration on the Hall Effect in Analysis of MPD Thruster

Tomoya ENDO, Hideki KAWAGUCHI and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

Authors have been discussing a method of numerical analysis of two dimensional Magnetoplasmadynamic (MPD) thruster and obtained good agreements with experimental results for total thrust force. However, the numerical method is still far from accomplished one, because some of the parameters reveal different values from experimental results, for example, extreme large temperature, etc. Then, one can rise an existence of unacceptable assumptions in the analysis as the reasons of the difficulties, for example, constant electric conductivity, neglect of the Hall effects, etc. From this point of view, authors discuss influences of the Hall effects in MPD thruster analysis in this paper.

2nd Japan-Korea Joint Symp. on Electrical Engineering, July 19-21, 1995, Teajon, Korea

## A numerical analysis of total shielding current of a Bulk HTSC with flux creep-flow model

H. WAKI, M. TSUCHIMOTO and T. HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

This paper describes evaluation of shielding current in high Tc superconductor based on flux creep-flow model. Numerical and experimental analyses are performed in order to investigate dynamic properties of the shielding current. It was confirmed that the dynamic properties of the shielding current was explained by the flux creep-flow model from the numerical results.

1st Japan-Kenya Joint Seminar on Applied Electromagnetics, August 24-25, 1995, Nairobi, Kenya

## Macroscopic modeling of motion of fluxoid in type II high Tc superconductor

K. MORIKAWA, M. TSUCHIMOTO and T. HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

The numerical model of fluxoid is solved with macroscopic equations to simulate the motion of the fluxoid. The numerical model is first discussed from relation with the frozen field model and the critical state model. Numerical code based on the eddy current analysis is applied to the problem. It is shown that numerical model from macroscopic approach is also useful to evaluate microscopic phenomena of the HTSC.

Int. Symp. on Non-linear Electromagnetic Systems, Sept. 17-20, 1995, Cardiff, U. K.

## Transient Scattering Phenomena Using Dirichlet Gauge BEM

Hideki KAWAGUCHI and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

Authors have been discussing gauge and boundary conditions of transient electromagnetic fields, which are bounded by a perfect conductor and shown that scalar and vector potentials can be taken to be zero on the perfect conductor boundary (Dirichlet gauge). Use of the Dirichlet gauge makes the boundary integral equation for transient electromagnetic fields being simple. And the simplification enables us to apply the boundary element scheme to the boundary integral equation. This means that one can numerically simulate the transient electromagnetic fields using the boundary element method (BEM) based on the Dirichlet gauge (Dirichlet gauge BEM).

Int. Symp. on Non-linear Electromagnetic Systems, Sept. 17-20, 1995, Cardiff, U. K.

## Numerical Analysis of MPD Thruster Considering the Hall Effect

Tomoya ENDO, Hideki KAWAGUCHI and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

Authors have been discussing a method of numerical analysis of two dimensional magneto-plasmadynamic (MPD) thruster and obtained good agreements with experimental results for the total thrust force. However, the numerical method is still far from accomplished one, because some of the numerical calculated parameters reveal different values from experimental results, for example, extreme large temperature, etc. Accordingly, assumptions, which have been introduced in the conventional numerical analysis, have to be reconsidered. From this point of view, this paper discusses influences of the Hall effect in MPD thruster analysis.

Int. Symp. on Non-linear Electromagnetic Systems, Sept. 17-20, 1995, Cardiff, U. K.

## Analysis of FEL Radiation Field Structure by Electron in Ponderomotive Potential

Hideki KAWAGUCHI, Junji MATSUOKA and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

This paper discusses radiation fields from the Free Electron Lasers (FEL) using a numerical simulation. Especially, electrons, which do a ponderomotive motion, are treated. Radiation fields by the relativistic electron shows very complex aspect, even if the electron motion is simple one, for example a circular motion. Accordingly, the electrons, which are in the FEL ponderomotive potential, also produces very complex structure electromagnetic radiation fields. It should be noted that there are two aspects in the " complex structure radiation fields ", that is to say, the complex frequency domain structure and the spatial domain structure. Therefore, the numerical simulation is also done by taking the both domains into account in this paper.

7th Biennial IEEE Conf. on
Magnetic Field Computation
March 18-20, 1996,
Okayama, Japan

## A Kinetic Analysis of Plasma Sheaths by Integral Equation Method

K. TSUBOTA, H. IGARASHI and T. HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

We report the analysis of plasma sheaths which occur between plasma and the wall. The plasma equation which governs sheaths has been already solved by Bissell et al, but the serious numerical errors occur in their results because the singularity exists in the equation. We consider the singularity and develop the method which regularizes the singularity, so that we confirm the errors are improved. We think this method is available for another calculation of the equation which includes the singularity.

7th Biennial IEEE Conf. on
Magmatic Field Computation
March 18-20, 1996,
Okayama, Japan

## Consideration of the Dirichlet-Gauge Boundary Element Method from the Topological Point of View

Hideki KAWAGUCHI, Makoto ISODA and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

This paper especially discusses the topological configuration for the considered region, that is necessitated by the use of the gauge transformation. The discussion is done using the four-dimensional space-time formulation. It is shown that the BEM which is based on potentials is almost free from topological ristrictions on the considered region.

7th Biennial IEEE Conf. on Magmatic Field Computation
March 18-20, 1996, Okayama, Japan

## Numerical Evaluation of Magnetization Properties of a Bulk HTSC with a Hole

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Faculty of Engineering, Hokkaido University, Sapporo, Japan
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Field-cooling and pulse magnetizations of a bulk high Tc superconductor (HTSC) with a hole are evaluated by using thin plate multi layers numerical codes. Dynamic effects of the pulse magnetization is analyzed with the flux creep-flow model. Merits and demerits of the HTSC with and without a hole are discussed from their practical applications as the trapped field magnet.

IEE 3rd Int. Conf. on Computation in Electromagnetics
April 10-12, 1996, Bath, U. K.

## Analysis of accelerator wake fields using boundary integral equation

Hideki KAWAGUCHI, Junji MATSUOKA and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

The paper discusses the particle accelerator wake fields analysis by using a boundary integral equation method. The boundary integral equation method is free from the above difficulties, because unknown variables are located only on boundaries. Especially, we use scalar and vector potentials as unknown variables in the boundary integral equation. Accordingly, the first part of this paper is devoted to a discussions of a possible gauge selection and an appropriate gauge condition. Based on the discussion on the gauge, a formulation of the numerical analysis and numerical simulations will follow.

IEE 3rd Int. Conf. on Computation in Electromagnetics
April 10-12, 1996, Bath, U.K.

## Regularization of Near Singularity in FE-BE Coupling Analysis of Three-Dimensional Static Magnetic Fields

H. IGARASHI, T. HONMA and A. KOST*
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In this paper, we present a regularization method of the near singularity of the kernel in an FE-BE coupling analysis of three-dimensional static magnetic fields. We analyze a magnetic head with a thin air gap using FE-BE coupling method and show that the present method yields reasonable magnetic fields in the vicinityof the air gap.

The 8th Congress of the International Cardiac Doppler Society, July 5-7, 1995, Sapporo, Japan

## Ultrasonic Measurement of Axial and Transverse Flow Components with a Single Transducer Using a Time-Domain Correlation Technique

K. YAMAMOTO and X. ZHANG
Division of Biomedical Engineering, Hokkaido University, Sapporo, Japan

We have newly developed a technique for measuring both the axial and the transverse components of flow velocity with a single transducer by a time-domain correlation technique. The measurement technique is based on the calculation of cross-correlation between RF echo signals taken at a certain repetition rate. The axial component of velocity can be determined from a time shift of the peak in the cross-correlation. The transverse component can also be obtained from the peak value of the correlation which decreases with time, depending on the magnitude of the transverse component. Through theoretical analysis, an equation to determine both component was derived.

The 4th Congress of AFSUMB, August 5-9, 1995, Beijing, China

## Ultrasonic Measurement of Flow Vector with a Single Transducer Using a Time-Domain Correlation Technique

K. YAMAMOTO, X. ZHANG, and M. SHIKUTANI
Division of Biomedical Engineering, Faculty of Engineering,
Hokkaido University, Sapporo, Japan

The present study reports a newly developed technique for measuring both the axial and the transverse components of flow velocity with a single transducer. Through theoretical analysis, we derived an equation with respect to the relationship between the correlation and the two components of flow velocity. Two kinds of experiments using a turn table and a flow tube were conducted to verify the validity of our method. Under various settings of the velocity and the beam angle, the velocity components and the angles were measured. In both experiments, measurement errors were less than 10% in velocity from 0.4 to 1.4 m/s and less than 4 degrees in beam angle from 90 to 50 degrees. The experimental results agreed well with the theoreticals.

17th Annual International Conference of the IEEE Engineering in MBS, Sept. 20-23, 1995, Montreal, Canada

## Dynamic Non-deterministic Characterization of HRV through Multiresolution Wavelet Decomposition

H. BAKARDJIAN and K. YAMAMOTO
Division of Biomedical Engineering, Hokkaido University, Sapporo, Japan

The present study investigates the multiresolution wavelet decomposition approach to the analysis of the heart rate variability (HRV) and the autonomic function. Autocorrelation analysis of the informative low- to high-frequency LF/HF ratio in time indicates that study of this parameter's long-term dependencies may prove diagnostically important. Return maps of the LF and HF octave bands of the multiresolution wavelet transform exhibited chaotic control behavior in the LF energy and repetitive patterns in the HF region of the HRV.

Beijing Meeting on Non-invasive Optical Diagnosis, May 23-24, 1996, Beijing, China

## Influence of Subcutaneous Fat Layer on Muscle Oxygenation Measurement Using NIRS

K. YAMAMOTO, M. NIWAYAMA, L. LIN, T. SHIGA*, N. KUDO, and K. SHIMIZU
Faculty of Engineering, Hokkaido University, apporo, Japan
*Omron Institute of Life Science Co., Ltd., Kyoto, Japan

Influence of the overlying tissues on muscle oxygenation measurement using reflectance NIRS was systematically studied. Monte Carlo simulation using a 3D model which consisted of fat and muscle layers was conducted, and optical density changes ($\Delta$OD) due to varied absorption were calculated under different conditions of fat layer thickness and source-detector distance. The proportion of detected light traveling through the muscle layer was greatly reduced by the presence of a fat layer. This tendency was also verified by experimental studies using a portable oxygen monitor, which was placed on the forearm and the vastus lateralis muscle. The thickness of the fat layer was measured by a diagnostic ultrasound equipment. There was a clear tendency for $\Delta$OD to be smaller in subjects whose fat layer was thick.

The 4th International Symposium on Phonosurgery, Oct. 27-29, 1995, Madrid, Spain

## Active Adjustments in The Neoglottis of Laryngectomees

Noriko NISHIZAWA Mamiko KOBASHI, Yukio INUYAMA, Makoto TAKAHASHI
Hokkaido University, Sapporo, Japan

Two TE speakers served as subjects to determine where and how adjustments for voicing distinction take place within the speech organs of laryngectomees. The speech materials were two-mora Japanese words which contained contrast of voiced/voiceless and geminated/ungeminated syllables in the intervocalic position. Neoglottal width which was monitored by photoglottography (PGG), EMG of the neoglottis and audio waveform were recorded during production of test words. Active articulatory adjustments for neoglottal width were found to reside within the neoglottis itself at least for the first subject. In the case of the second subject, however, physiological background of voicing distinction remains unknown. Coordination between the neoglottis and the supra-neoglottal structure must further be evaluated in association with neoglottal width and trans-neoglottal pressure gradient.

Xth World Congress of The International Society for Artificial Organs, November 11-14, 1995, Taipei, Taiwan

## Improvement of The Frictional Surfaces of Artificial Joint

Ikuya NISHIMURA, Toshio YUHTA, Yoshimori MITAMURA*,
Hirosi ITOH**, Takeshi MATSUNO**, Kiyoshi KANEDA**
Dept. of Biomedical Engineering, Faculty of Engineering, Hokkaido University
*Dept. of Electronic and Information Engineering, School of Engineering, Hokkaido Tokai University
**Dept. of Orthopaedics, School of Medicine, Hokkaido University

To overcome the wear problems associated with artificial joint materials, new surface structures with regular patterning were designed and fabricated. The lubrication properties were studied to evaluate the wear of the frictional surfaces.

The time-dependent changes of frictional forces between smooth or patterned ultrahigh molecular weight polyethylene and Co-Cr alloy were measured, and the surface morphological changes were observed.

The smooth surface without patterning showed rapid increase in the frictional force. However the frictional force was very low by the patterned surface. After experiments, many wear particles were observed on the smooth surface. However, no particles were observed on the patterned surface. These results demonstrated that the lubrication properties could be improved by patterning of the frictional surfaces. The surface patterning have a good effect on preventing the wear of the frictional surface. The life of the artificial joint could be extended by the patterning on the frictional surfaces.

42nd Annual Meeting, Orthopaedic Research Society, February, 1996, Atlanta, USA

## Modification of the Frictional Surface of Total Joint Arthroplasty

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The frictional surface of the artificial joint produces wear debris of ultrahigh molecular weight polyethylene (UHMWPE). The UHMWPE debris has documented to stimulate celluar osteolysis, resulting in loosening of the prosthesis.

We designed a new structure of the frictional surface which reduces the wear rate of

UHMWPE, and a pin on disc type lubrication experiment was performed between a Co-Cr pin and UHMWPE disc. The patterned sample demonstrated about 29% lower and steadier frictional force than the non-patterned sample. The average wear depth after the experiment was 8 $\mu$m in the patterned sample, and 12$\mu$m in the non-patterned sample.

Xth World Congress of the International Society for Artifical Organs, November 14-18, 1995, Taipei, Taiwan

## Evaluation of Newly Designed Adsorbents for Selective Removal of Glycosylated Proteins from Human Plasma

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Modification of plasma proteins, such as oxidation or glycosylation, are obserbed among diabetic subject. It has been proposed that modification of plasma low density lipoproteins (LDL) are responsible for the progression of atherosclerosis. In this study, new materials were synthesized and examined if they can remove glycosylated LDL (glc-LDL) or glycosylated proteins (glc-proteins) selectively from plasma in vitro. Glycosylated albumin was used as model for glc-proteins. 4-vinylphenyl boronic acid (VPB) and acrylic acid (AA) were copolymerized in the various AA ratios of 20, 40, 50, 80 mol%, namely AA20, AA40, AA50, AA80. In three kinds of phosphate buffered solutions (pH 7.4) containing (i) glc-alb (ii) glc-abl+glucose (iii) glc-alb+IgG+fibrinogen were used. Glass beads (average diameter 86 $\mu$m) precoated with copolymers were immersed in the solutions and incubated for 2hours at 37°C. The amount of adsorbed glc-proteins was determined from the difference between initial and equilibrium concentrations of the solutions by spectrophotometry. The results showed AA40 and AA50 adsorbed a large amount of glc-alb and the properties were nor inhibited in the presence of glucose or other plasma proteins. In addition, their adsorption activities for glc-LDL are under investigation.

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## Evaluation of Optimum Pulsed Magnetic Fields for Macrophage Activation

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We have reported that pulsed magnetic fields (PMFs) can augment macrophage (M$\phi$) activation and are useful for extracorporeal immunomodulations. To optimize the PMF conditions, the effects of PMF exposure time and frequency were studied. Murine peritoneal M$\phi$ prepared by thioglycollate stimulation were incubated with INF-$\gamma$ for 4h followed by LPS activation for 48h. The INF activation process was exposed to the PMF which was generated by a Helm-hortz coil, and the frequency was varied from 10 to 250 Hz with the duty of 50%. The degree of M$\phi$ activation was evaluated by the measurements of NO productions and compared with the control samples which was placed in a different CO2 incubator. When the PMF duration of 50 Hz was varied from 10 min. to 4h, the 20 min. exposure was most effective and showed 2.3 times more production of NO than the control. This result suggests the PMF effect is mainly due to the $Ca^{2+}$ influx augmentation which was previously shown by $Ca^{2+}$ concentration measument in M$\phi$. Among the frequencies evaluated, 25 Hz showed the most effective and 10 or 250 Hz induced no effect. These results clarified the optimum conditions of PMF for the application of immunomodulations.

Xth World Congress of the International Society for Artificial Organs, Nobember 14-18, 1995, Taipei, Taiwan

## Effect of Compliance Structure on Pitting of a Leaflet by Accelerated Fatigue Test.

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The accelerated fatigue tester which involve compliance structures were developed. Air rooms were separated by elastic diaphragm in the pipe wall near the tested valve. And effect of the compliance on pitting of a leaflet was evaluated. As a preliminary test, duralumin disks were used. Tests run in 600 cycles/min. for 15h. In all cases, many pits on the inletside of those. In order to evaluate the effect on the compliance, pits (larger than 30 micro meters) in

the corresponded area were counted. Number, size and depth of pits were clearly increased by the existence of the wall compliance. It is suggested that compliance structure must be account for design of an accelerated fatigue tester from the view of cavitation erosion.

CLEO/Pacific Rim'95, The Pacific Rim Conference on Lasers and Electro-Optics, Chiba, Japan, July 10-14, 1995.

## CT Imaging of Biological Body with CW Laser Light

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The strong scattering from tissues has been identified as a difficult problem to realize the CT imaging of a living body. Two techniques were newly developed. One was the scattering angle differential technique which suppresses the effect of scattering in the imaging through diffuse media. Another technique was the contact technique which overcomes the problems of the reflection and the refraction at the air-tissue interface. A measurement system was developed to use both techniques simultaneously. The feasibility of the optical CT with CW light was verified using the developed system.

OSA Topical Meeting, Advances in Optical Imaging and Photon Migration, Orland, Florida, U.S.A., March 18-20, 1996.

## Imaging of Physiological Functions by Laser Transillumination

Koichi SHIMIZU and Katsuyuki YAMAMOTO
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Attempts were made to visualize the functional change inside a living biological body using a transillumination technique. With a near-infrared light, the transillumination images of a mouse abdomen and a rat brain were obtained. To examine the feasibility of functional imaging, a localized hypoxia was made in each of above body parts. They were visualized using transillumination images of multiple wavelengths of light. It was found that the changes in the brain blood volume and in the oxygenation state of tissues could be detected noninvasively. In

this way, the spatial distribution of these changes could be visualized in the transillumination images of a living body. Through this study, the feasibility of optical trans-body imaging of physiological functions was verified.

OSA Topical Meeting, Advances in Optical Imaging and Photon Migration, Orland, Florida, U.S.A., March 18-20, 1996.

## CT Imaging of Biological Body with CW Laser Light

Masataka KITAMA, Koichi SHIMIZU and Katsuyuki YAMAMOTO
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The feasibility of an optical CT with a CW light was investigated. A technique called a scattering angle differential technique has been newly developed to suppress the effect of scattering in the imaging through diffuse media. The effectiveness of this technique was demonstrated in the CT imaging of a model phantom. However, it was found in experiments that this technique alone was not effective with a living mouse. The problem was found to be the reflection and the refraction at the air-tissue interface. Another technique called a contact technique was newly developed to overcome this problem. A measurement system was developed to use both techniques simultaneously. Using this system, the CT imaging of a mouse abdomen was attempted. Though the spatial resolution was poor, the existence of a liver and kidneys were recognized in the CT image of a living mouse.

Non-invasive Optical Diagnosis, Beijing Meeting, Beijing, P. R. China, May 23-24, 1996.

## Fundamental Study for Reconstruction of Optical CT Images

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To suppress the scattering effect in a reconstructed image of an optical CT, a fundamental study has been conducted on the deconvolution technique using a point spread function (PSF). PSF's were obtained at different depths in a scattering medium. It was shown that the blur-

ring effect due to the scattering was suppressed effectively if the PSF of an appropriate depth was used. The spatial resolution could be improved to the half of the original value. This technique was applied to an optical CT imaging. The effect of scattering suppression was demonstrated in the CT imaging, as well. At the same time it was made clear that the use of a single PSF was not sufficient to recover the image of an internal structure as if it were in clear water.

Non-invasive Optical Diagnosis, Beijing Meeting, Beijing, P. R. China, May 23-24, 1996.

## CT Imaging of Biological Body With CW Light

Masataka KITAMA
Hokkaido Institute of Technology, Sapporo, 006, Japan
Koichi SHIMIZU and Katsuyuki YAMAMOTO
Department of Bioengineering, Faculty of Engineering,
Hokkaido University, Sapporo, 060, Japan

A fundamental study was conducted to examine the feasibility of an optical CT with a CW light. A technique called " a scattering angle differential technique " has been newly developed to suppress the effect of scattering in the imaging through diffuse media. The effectiveness of this technique was demonstrated in the CT imaging of a model phantom. However, it was found in experiments that this technique alone was not effective with a living mouse. The problem was found to be the reflection and the refractoion at the air-tissue interface. Another technique called " a contact technique " was newly developed to overcome this problem. A measurement system was developed to use both techniques simultaneously. Using this system, the CT imaging of mouse abdomen was attempted. Though the spatial resolution was poor, the existence of a liver and kidneys were recognized in the CT image of a living mouse.

Non-invasive Optical Diagnosis, Beijing Meeting, Beijing, P. R. China, May 23-24, 1996.

## Transillumination Imaging of Physiological Functions

Yoshinori TAKA, Koichi SHIMIZU, Kaoru SAKATANI and Katsuyuki YAMAMOTO
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A fundamental study has been conducted to visualize the functional change inside a living biological body using a transillumination technique. With a near-infrared light, the transillumination images of a mouse abdomen and a rat brain were obtained. To examine the feasibility of functional imaging, a localized hypoxia was made in each of above body parts. They were visualized using transillumination images of multiple wavelengths of light. It was found that the changes in the brain blood volume and in the oxygenation state of tissues could be detected noninvasively. In this way, the spatial distribution of these changes could be visualized in the transillumination images of a living body. Through this study, the feasibility of optical trans-body imaging of physiological functions was verified.

Non-invasive Optical Diagnosis, Beijing Meeting, Beijing, P. R. China, May 23-24, 1996.

## Cross-Sectional Imaging of Diffuse Medium Using Backscattered Light

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A new technique was developed to reconstruct the cross-sectional image of a diffuse medium using the backscattered light. The subject is divided into some imaginary layers. The probabilities of the photon propagation in each layers are obtained beforehand either in the Monte Carlo simulation or in the measurement with a model phantom. A short pulse of light is illuminated on the body tissue, and the output pulse shape is obtained in the time-resolved measurement. The absorbance of each layer is obtained by solving linear simultaneous equations that were given from the measured pulse shape. The equations were derived in the linear approximation of the fundamental equation for the light attenuation due to the scattering and the absorption of the diffuse medium. To examine the applicability of this technique to a diffuse medium, a computer simulation based on the Monte Carlo method was conducted. When the variation of the absorption was small among layers, the reconstructed distri-

bution agreed well with the given distribution. However, with large variation, the error became large particularly in deep layers.

SPIE's Photonics West '96
BiOS'96-Biomedical Optics
San Jose, U. S. A., Jan. 27-Feb. 2, 1996.

## Fabrication of dielectric-coated silver hollow glass waveguides for the infrared by liquid flow coating method

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Polyimide-coated silver hollow glass waveguides with small losses have been fabricated for transmission of Er: YAG laser light. The total loss is around 0.7 dB for the straight waveguide with an inner diameter of 700 micrometers and the length of 2.3 m including a coupling loss from a laser. Even when the waveguide is bent to 180 degrees with a bending radius of 18 cm, the total loss is around 1 dB for the input energy of 500 mJ.