

14th International Symposium on Magnetic Bearings 2014

Linz, Austria
11-14 August 2014

ISBN: 978-1-5108-2260-3

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571



Some format issues inherent in the e-media version may also appear in this print version.

Copyright© (2014) by Linz Center of Mechatronics GmbH
All rights reserved.

Printed by Curran Associates, Inc. (2016)

For permission requests, please contact Linz Center of Mechatronics GmbH
at the address below.

Linz Center of Mechatronics GmbH
Altenberger Straße 69
4040 Linz
Osterreich

Phone: +43 732 2468-6002
Fax: +43 732 2468-6005

office@lcm.at

Additional copies of this publication are available from:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571 USA
Phone: 845-758-0400
Fax: 845-758-2633
Email: curran@proceedings.com
Web: www.proceedings.com

ISMB 2014 Table of Contents

Keynote Speakers

Control of a Flexible Rotor AMB Compressor Test Rig with Aerodynamic Cross Coupling	785
Simon Mushi, Paul Allaire <i>Rotor Bearing Solutions International, LLC, United States</i>	
Overview on Various Types of AMBs & their Respective Potential for Applications.....	802
Hannes Bleuler <i>EPFL Lausanne, LSRO-IMT, Switzerland</i>	
Electrical drive systems with active magnetic bearings in industrial applications - possibilities and challenges.....	804
Matthias Kroll <i>LEVITEC GmbH, Germany</i>	
Magnetic Bearings: Application to High Speed Textile Processing.....	808
Jiří Sloupenský <i>Product Research Reiter, Czech Republic</i>	
Industrialisation Trends for Active Magnetic Bearings in the Turbomachinery Industry ISMB 14 Systems	828
Michael K. Swann <i>Waukesha Magnetic Bearings, United States</i>	

Active Magnetic Bearings I

Comparative Study of Axial/Radial Magnetic Bearing Arrangements for Turbocompressor Applications	1
Alexei Filatov, Larry Hawkins <i>Calnetix Technologies, United States</i>	
Field Experience with Automated Tools in Both Remote and Local Commissioning of Active Magnetic Bearing Systems	7
Richard Jayawant, Nigel Davies <i>Waukesha Magnetic Bearings, United Kingdom</i>	
Linear and Nonlinear Control of a Three Pole Combined Active Magnetic Bearing - a Comparison	13
Erik Fleischer, Wilfried Hofmann <i>Technische Universität Dresden, Germany</i>	

Active Magnetic Bearings II

Research on Redundancy of Weak Coupling Radial Magnetic Bearing 19
Xiaoguang Wang, Qian Liu, Yefa Hu, Haohui Chen, Qingling Geng
Wuhan University of Technology, China

Active Magnetic Bearings with Position and Flux Observer..... 25
Angelo Bonfitto, Lester Daniel Suarez Cabrera, Andrea Tonoli
Politecnico di Torino, Italy

Interconnected Four Poles Magnetic Bearings Simulations and Testing 30
Domingos David², Jose Santisteban², Afonso Celso del Nero Gomes¹
¹*Universidade Federal do Rio de Janeiro, Brazil*; ²*Universidade Federal Fluminense, Brazil*

Active Thrust Bearings

Segmented Magnetic Thrust Bearings: Analytic Models and Predictions of Significant Improvement in Dynamic Performance	36
Zackary Whitlow, Roger Fittro, Carl Knospe <i>UNiversity of Virginia, United States</i>	
Design of a Highly Reliable Fan with Magnetic Bearings.....	42
Gerald Jungmayr ² , Hans-Jörg Berroth ¹ , Martin Panholzer ² , Edmund Marth ² , Wolfgang Amrhein ² , Frank Jeske ¹ , Martin Reisinger ³ ¹ <i>ebm-papst St. Georgen GmbH & Co. KG, Germany</i> ; ² <i>Johannes Kepler Universität Linz, Austria</i> ; ³ <i>Linz Center of Mechatronics GmbH, Austria</i>	
Novel Permanent-Magnet-Biased Axial Hybrid Magnetic Bearings Without a Thrust Disc	48
Pengfei Zhang, Zhiheng Wang, Guang Xi <i>Xi'an Jiaotong University, China</i>	

Advanced Control I

LQG Control of an Active Magnetic Bearing with a Special Method to Consider the Gyroscopic Effect	54
Markus Hutterer, Matthias Hofer, Thomas Nenning, Manfred Schrödl <i>Technische Universität Wien, Austria</i>	
Feedback Compensation of Tool Deflection in a High-Speed Machining AMB Spindle	60
Alexander Smirnov ² , Alexander Pesch ¹ , Adam Wroblewski ¹ , Olli Pyrhönen ² , Jerzy Sawicki ¹ ¹ Cleveland State University, United States; ² Lappeenranta University of Technology, Finland	
Feedback Control of a Magnetic Bearing Using Fusion of Rotor Acceleration and Position Measurements	65
Matthew Cole, Samuel Jimenez, Patrick Keogh <i>University of Bath, United Kingdom</i>	
Anti-Windup Control of Active Magnetic Bearings Subject to Voltage Saturation.....	71
Jinxiang Zhou, Jiancheng Fang, Yin Zhang, Yinxiao Jiang <i>Beijing University of Aeronautics and Astronautics / Beihang University, China</i>	
Advanced Controller of a Hybrid Foil-Magnetic Bearing.....	77
Ye Tian, Yanhua Sun, Lie Yu <i>Xi'an Jiaotong University, China</i>	

Advanced Control II

A Notch Filter for Magnetically Suspended Rotors Based on Rotating Coordinate Transformation..... 83

Shiqiang Zheng¹, Rui Feng²

¹Beijing University of Aeronautics and Astronautics / Beihang University, China; ²Huawei Technologies Co. Ltd, China

Identification of Magnetic Bearing System Using a Novel Subspace Identification Method..... 87

Zhe Sun, Jingjing Zhao, Zhengang Shi
Tsinghua University, China

Adaptive Kalman Filter for Active Magnetic Bearings Using Softcomputing 91

Li Li, Wolfgang Kästner, Frank Worlitz

Hochschule Zittau/Goerlitz - University of Applied Sciences, Germany

Backup/Touch Down-Bearings

Dynamics of Magnetic Suspended Rotor Drop on Auto-Eliminating Clearance Auxiliary Bearings	99
Chaowu Jin ² , Qiuping Fan ² , Yili Zhu ¹ , Chengtao Yu ² , Xianxi Xia ²	
¹ Changzhou Institute of Technology, China; ² Nanjing University of Aeronautics and Astronautics, China	
Research and Experiment of Auxiliary Bearings with No Lubrication for Helium Blower of HTR-10.....	104
Guojun Yang, Zhengang Shi, Xingnan Liu, Jingjing Zhao	
Tsinghua University, China	
High Speed Backup Bearings for Outer-Rotor-Type Flywheels - Proposed Test Rig Design.....	109
Lukas Quurck, Hendrik Schaede, Michael Richter, Stephan Rinderknecht	
Technische Universität Darmstadt, Germany	
Active Touchdown Bearing Control for Recovery of Contact-Free Rotor Levitation in AMB Systems	115
Peichao Li, Necip Sahinkaya, Patrick Keogh	
University of Bath, United Kingdom	
Numerical and Experimental Results of Auxiliary Bearings Testing on a High Speed Test Rig.....	121
Tim Collins, Andrea Masala, Richard Shultz, Zenglin Guo	
Waukesha Magnetic Bearings, United Kingdom	

Bearingless 3-Phases Systems

Reduction of Rotor Vibration in Passively Stabilized Direction in Single-Drive Bearingless Motor..... 127

Hiroya Sugimoto, Seiyu Tanaka, Akira Chiba
Tokyo Institute of Technology, Japan

Experimental Characterization of a Bearingless Rotating Field Axial-Force/Torque Motor..... 132

Walter Bauer, Paul Freudenthaler, Wolfgang Amrhein
Johannes Kepler Universität Linz, Austria

Realization of Magnetic Suspension and Motor Operation with One Three-Phase Voltage Source Inverter Using a Zero-Phase Current 138

Junichi Asama¹, Yusuke Fujii¹, Masato Fukuyo¹, Takaaki Oiwa¹, Akira Chiba²
¹*Shizuoka University, Japan*; ²*Tokyo Institute of Technology, Japan*

Bearingless Motors I

Study on Bearingless Motor with Rectified Circuit Coil..... 142

Kunihiko Tachibana, Koichi Oka
Kochi University of Technology, Japan

Robust Speed Controller of a Bearingless AC Motor Type Divided Winding, Based on a Conventional Squirrel Cage Induction Motor..... 146

Luciano Pereira dos Santos¹, José Soares Batista Lopes¹, Valcí F. Victor², André L. Maitelli³, Andrés Ortiz Salazar³

¹*Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Sul, Brazil;*

²*Instituto Federal de Educação, Ciência e Tecnologia do Tocantins, Brazil;* ³*Universidade Federal do Rio Grande do Norte, Brazil*

Rotor Flux Observer Based Neuro-Fuzzy Techniques to Speed Vector Control of a Bearingless AC Motor..... 150

José Soares Batista Lopes¹, Luciano Pereira dos Santos¹, José Alvaro de Paiva¹, Valcí F. Victor², André L. Maitelli³, Andrés Ortiz Salazar³

¹*Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Sul, Brazil;*

²*Instituto Federal de Educação, Ciência e Tecnologia do Tocantins, Brazil;* ³*Universidade Federal do Rio Grande do Norte, Brazil*

Bearingless Motors II

Performance Assessment of a Self-Bearing Motor: an Application of ISO 14839..... 155

José Dalvio Ghirello Garcia, Afonso Celso del Nero Gomes, Richard Magdalena

Stephan

Universidade Federal do Rio de Janeiro, Brazil

Vibration Suppression of a Middle-Point Current-Injection Type Bearingless Motor at 50000r/min 159

Yusuke Uemura, Takayuki Nakahata, Akira Chiba

Tokyo Institute of Technology, Japan

Characteristics of Torque and Suspension Force in a D-Q Axis Current Control Bearingless Motor..... 163

Masahide Ooshima, Yuto Gomi

Tokyo University of Science, Suwa, Japan

Bearingless Pumps

- Thin Maglev Ventricular Assist Device with Radial Type Self-Bearing Motor 168**
Michiko Murakami², Toru Masuzawa², Shoichi Yoshida², Hiroyuki Onuma¹, Takashi Nishimura³, Syunei Kyo³
¹Ibaraki National College of Technology, Japan; ²Ibaraki University, Japan; ³University of Tokyo, Japan
- Evaluation of Magnetic Suspension Characteristics and Levitation Performance of a Centrifugal Blood Pump Using Radial Type Self-Bearing Motor 174**
Hiroyuki Onuma¹, Toru Masuzawa²
¹Ibaraki National College of Technology, Japan; ²Ibaraki University, Japan
- Development of Highly Efficient Magnetic Bearing and Application to Ultra-Low Temperature Fluid Pump 180**
Yohji Okada¹, Hironari Suzuki¹, Ken-Ichi Matsuda¹, Ryou Kondo¹, Masato Enokizono²
¹Ibaraki University, Japan; ²Oita University, Japan
- A Permanent Magnet Free Bearingless Motor for Disposable Centrifugal Blood Pump 183**
Jun Rao, Wataru Hijikata, Tadahiko Shinshi
Tokyo Institute of Technology, Japan
- Radial Position Active Control of Double Stator Axial Gap Self-Bearing Motor for Paediatric VAD 187**
Masahiro Osa¹, Toru Masuzawa¹, Naoki Omori¹, Eisuke Tatsumi²
¹Ibaraki University, Japan; ²National Cerebral and Cardiovascular Center, Japan

Bearingless Slice Motors I

Influence of Fault-Tolerant Stator Structure on Performance of Permanent Magnet Bearingless Slice Machines	193
Qiang Ding, Guyu Wu, Zhiquan Deng, Xiaolin Wang <i>Nanjing University of Aeronautics and Astronautics, China</i>	
Comparison of Homopolar and Heteropolar Bearingless Reluctance Slice Motor Prototypes	199
Wolfgang Gruber ¹ , Walter Bauer ¹ , Karlo Radman ² ¹ <i>Johannes Kepler Universität Linz, Austria;</i> ² <i>University of Rijeka, Croatia</i>	
Two Mathematical Models of Five-Phase High Speed Permanent Magnet Bearingless Slice Motor	204
Tuo Cheng Ni, Xiaolin Wang, Qiang Ding, Guyu Wu <i>Nanjing University of Aeronautics and Astronautics, China</i>	

Bearingless Slice Motors II

Loss Analysis of a Bearingless Flux-Switching Slice Motor 210

Karlo Radman², Wolfgang Gruber¹, Neven Bulic²

¹Johannes Kepler Universität Linz, Austria; ²University of Rijeka, Croatia

A 5-DOF Active Controlled Disk Type PM Motor with Cylindrical Flux Paths..... 216

Satoshi Ueno, Takuya Fukuura, Tran Van Toan

Ritsumeikan University, Japan

A Novel Stabilization Technique for Magnetically Levitated Disk Drives 220

Hubert Mitterhofer, Gerald Jungmayr, Wolfgang Amrhein

Johannes Kepler Universität Linz, Austria

Bearingless SRM

Decoupling Control for Bearingless Synchronous Reluctance Motor Based on SVM with Ant Colony Optimization Algorithm..... 226

Huangqiu Zhu, Xiaoyan Diao, Enxiang Xu, Li Cao
Jiangsu University, China

Mass Eccentricity Compensation Research of Bearingless Switched Reluctance Motor..... 232

Jie Chen¹, Zhiquan Deng¹, Yan Yang², Xin Cao¹, Qiang Ding¹
¹*Nanjing University of Aeronautics and Astronautics, China;* ²*Nanjing University of Posts and Telecommunications, China*

Eccentricity Analysis and Efficiency Estimation of 12/14 Hybrid Stator Pole Bearingless SRM..... 237

Zhenyao Xu, Jin-Woo Ahn
Kyungsung University, Korea, South

Development Tools

Rotordynamic Simulations with MADYN 2000 No Paper
Joachim Schmied
DELTA JS AG, Switzerland

MagOpt - Optimization Tool for Mechatronic Components 243
Siegfried Silber², Werner Koppelstätter², Günther Weidenholzer², Gerd Bramerdorfer¹
¹*Johannes Kepler Universität Linz, Austria;* ²*Linz Center of Mechatronics GmbH, Austria*

Coupled Mechanical and Electromagnetic Optimization of High Speed Rotors 247
Daniel Reischl, Alexander Dorninger, Armin Fohler, Johannes Gerstmayr, Werner Koppelstätter, Siegfried Silber, Simon Weitzhofer
Linz Center of Mechatronics GmbH, Austria

Code Agros2D and Possibilities of its Use for Modeling and Design of Magnetic Bearings 251
Pavel Karban, Frantisek Mach, Pavel Kus, Lukas Korous, Ivo Doležel
University of West Bohemia, Czech Rep.

Electrodynamic Bearings

Review of Electrodynamic Bearings	257
Torbjörn Lembke <i>Lembke Elektromekaniska Verkstad LEV AB, Sweden</i>	
Test and Theory of Electrodynamic Bearings Coupled to Active Magnetic Dampers	263
Fabrizio Impinna, Joaquim Girardello Detoni, Andrea Tonoli, Nicola Amati, Maria Pina Piccolo <i>Politecnico di Torino, Italy</i>	
Stability of a 4 Degree of Freedom Rotor on Electrodynamic Passive Magnetic Bearings	269
Joaquim Girardello Detoni, Fabrizio Impinna, Nicola Amati, Andrea Tonoli, Maria Pina Piccolo, Giancarlo Genta <i>Politecnico di Torino, Italy</i>	
Impact of the Yoke Material on the Performance of Wounded Electrodynamic Bearings	275
Corentin Dumont, Virginie Kluyskens, Bruno Dehez <i>Université catholique de Louvain, Belgium</i>	
Optimization of a New Radial Electrodynamic Damper	281
Virginie Kluyskens, Bruno Dehez <i>Université catholique de Louvain, Belgium</i>	

Fault Detection and Diagnosis

Active Magnetic Bearings for Rolling Element Bearings Outer Race Incipient Defect Diagnosis..... 286

Yuanping Xu¹, Jin Zhou¹, Long Di², Longxiang Xu¹

¹Nanjing University of Aeronautics and Astronautics, China; ²University of Virginia, United States

Application of a Magnetic Actuator as an External Excitation Source in Fault Detection 290

Ricardo Ugliara Mendes, Gregory Bregon Daniel, Helio Fiori de Castro, Katia Lucchesi Cavalca

Universidade Estadual de Campinas, Brazil

Flexible Rotor Control

Energy Cost Assessment of the Active Control of a the Flexible Rotor Supported by AMB	296
Benjamin Defoy ¹ , Thomas Alban ¹ , Jarir Mahfoud ²	
¹ <i>GE Oil & Gas, France</i> ; ² <i>Université de Lyon, France</i>	
Optimization Based AMB Controller Design and Verification for Flexible Rotors	300
Bin Liu ¹ , Johan Sjöberg ³ , Antti Laiho ²	
¹ <i>ABB Corporate Research, Sweden</i> ; ² <i>ABB Discrete Automation and Motion, Finland</i> ; ³ <i>Linköping University, Sweden</i>	
Robust Control and Loop Shaping Design with the Application to Flexible Rotor Levitated with AMBs	304
Goranka Štimac, Sanjin Braut, Roberto Žigulic, Ante Skoblar	
<i>University of Rijeka, Croatia</i>	

Flywheels I

A Method of Simple Adaptive Control for MIMO Nonlinear AMB-Flywheel Levitation System	309
Yong He, Kenzo Nonami, Fumiya Shimizu <i>Chiba University, Japan</i>	
Benchmark and Verification of Control Algorithm for Flywheel with Active Magnetic Bearing on Electric Vehicle & Proposal of New SAC Algorithm (Epsilon1 Modification and Bias Variable Gamma p Approach)	313
Fumiya Shimizu, Kenzo Nonami <i>Chiba University, Japan</i>	
Integrated Controller Based on Floating Point Operations in an FPGA for a Magnetically Suspended Flywheel	319
Li Zhang, Kun Liu, Kai Xiao <i>National University of Defense Technology, China</i>	

Flywheels II

- Emulation of Energy Storage Flywheels on a Rotor-AMB Test Rig 326**
Xujun Lyu², Long Di¹, Se Young Yoon¹, Zongli Lin¹, Yefa Hu²
¹University of Virginia, United States; ²Wuhan University of Technology, China
- An Energy Storage Flywheel Supported by Hybrid Bearings 332**
Kai Zhang, Xingjian Dai, Jinping Dong
Tsinghua University, China
- Flywheel Energy Storage System to be Applied for the Railway System 337**
Jun-Ho Lee
Korea Railroad Research Institute, Korea, South
- Losses in an Outer-Rotor-Type Kinetic Energy Storage System in Active Magnetic Bearings 342**
Hendrik Schaede, Michael Richter, Lukas Quurck, Stephan Rinderknecht
Technische Universität Darmstadt, Germany

Kinetic Energy Storage Systems I

Topology Optimization of a Flywheel Energy Storage Rotor Using a Genetic Algorithm 347

Thomas Hinterdorfer, Alexander Schulz, Harald Sima, Stefan Hartl, Johann Wassermann
Technische Universität Wien, Austria

High Speed Flywheels for Vehicular Applications..... 353

Johan Lundin, Tobias Kamf, Johan Abrahamsson, Juan de Santiago, Magnus Hedlund, Hans Bernhoff
Uppsala University, Sweden

Increasing Bearing Life-Time of Mobile Flywheels by Using Bearing-Less Drive Methods 360

Manes Recheis
Technische Universität Graz, Austria

Kinetic Energy Storage Systems II

- Kinetic Energy Storage: an Ideal Application for Magnetic Bearings 366**
Giancarlo Genta
Politecnico di Torino, Italy
- Modeling and Control of a Hybrid Magnetic Bearing in a Ring-Type Flywheel System..... 372**
Chow-Shing Toh, Shyh-Leh Chen
National Chung Cheng University, Taiwan
- Superconducting Bearing Design for Outer Rotor Flywheel Using Lumped Parameter Techniques 377**
Clay Hearn, Siddharth Pratap, Dongmei Chen, Raul Longoria
University of Texas at Austin, United States
- Energy Storage Flywheel Magnetic Bearing System - Magnetic Linear Circuit Vs. 3-D Finite Element Model 383**
Arunvel Kailasan¹, Tim Dimond², Paul Allaire²
¹Gardner Denver, Inc., United States; ²Rotor Bearing Solutions International, LLC, United States
- Multicriteria Design Process for Outer-Rotor Kinetic Energy Storage Systems 390**
Maximilian Schneider, Hendrik Schaede, Stephan Rinderknecht
Technische Universität Darmstadt, Germany

Linear Actuators

- Novel Cylindrical Magnetic Levitation Stage with High Precision Motion 396**
Jeong-Woo Jeon, Chang-Lin Lee, Hyeon-Seok Oh, Jong-Moon Kim
Korea Electrotechnology Research Institute, Korea, South
- Active Reduction of Bearing Forces of Short Stroke Linear Actuators 401**
Florian Poltschak
Johannes Kepler Universität Linz, Austria
- Design of Electromagnetic Levitation Linear Bearing for FPD Glass Delivery Applications 407**
Kichang Lee¹, Jun-Young Baek³, Ji-Won Kim¹, Min-Hyuk Ahn¹, Tae-Uk Jung², Min-Cheol Lee³
¹*Korea Electrotechnology Research Institute, Korea, South*; ²*Kyungnam University, Korea, South*; ³*Pusan National University, Korea, South*
- An Eddy Current Damper for Reaction Force Compensation for a Linear Motor Motion Stage 412**
Hyeong Joon Ahn, Yo Han You
Soongsil University, Korea, South
- Design of Novel Bearing-Less Electromagnetic Actuator in Valve Operation..... 416**
Frantisek Mach, Pavel Karban, Ivo Doležel
University of West Bohemia, Czech Rep.

MagLev Technology for Artificial Hearts

Magnetically Suspended Motor System for Artificial Hearts and Blood Pumps 421

Toru Masuzawa

Ibaraki University, Japan

Magnetic Bearing System for Left Ventricular Assist Artificial Heart Pump - Combined Active and Passive Configuration 426

Paul Allaire², Wei Jiang³, Arunvel Kailasan¹, Tim Dimond²

¹Gardner Denver, Inc., United States; ²Rotor Bearing Solutions International, LLC, United States; ³University of Virginia, United States

Development of Extracorporeal Maglev Blood Pumps 433

Tadahiko Shinshi², Wataru Hijikata², Taichi Mamiya², Setsuo Takatani¹

¹MedTech Heart Inc., Japan; ²Tokyo Institute of Technology, Japan

Optimization Design of Magnetically Suspended System for the BiVACOR Total Artificial Heart 437

Nobuyuki Kurita¹, Daniel Timms³, Nicholas Greatrex³, Matthias Kleinheyser³, Toru Masuzawa²

¹Gunma University, Japan; ²Ibaraki University, Japan; ³Texas Heart Institute, United States

Magnetic Bearings in Energy Technology

- Landing Tests with a 6300rpm, 9t AMB Rotor in Rolling Element Back-Up Bearings..... 441**
Joachim Denk², Bert-Uwe Köhler², Guenther Siegl², Peter Siebke¹
¹*Schaeffler Technologies GmbH & Co. KG, Germany*; ²*Siemens AG, Germany*
- Simulation and Experimental Validation of a 9t AMB Rotor Landing in Rolling Element Back-Up Bearings 448**
Guenther Siegl, Theodora Tzianetopoulou, Joachim Denk
Siemens AG, Germany
- A Novel Rolling Element Back-Up Bearing for a 9 T Rotor Application 454**
Peter Siebke, Hermann Golbach
Schaeffler Technologies GmbH & Co. KG, Germany
- Qualification of Magnetic Bearings for Industrial Turbines 459**
Christoph Grund, Detlef Haje
Siemens AG, Germany
- Test Field for Magnetic Bearing Applications Under Extreme Conditions 477**
Stephan Duesterhaupt, Holger Neumann, Christian Panescu, Torsten Rottenbach, Frank Worlitz
Hochschule Zittau/Goerlitz - University of Applied Sciences, Germany
- Backup Bearing Modelling for Turbo Machines with High Axial and Radial Loads 482**
Jan Janse van Rensburg², Christian Vanek¹, Frank Worlitz¹
¹*Hochschule Zittau/Goerlitz - University of Applied Sciences, Germany*; ²*North-West University, South Africa*

Magnetic Suspension Systems

Fabrication of Non-Contact Carrier System Using Solar Magnetic Suspension 487

Yuji Ishino, Masaya Takasaki, Takeshi Mizuno
Saitama University, Japan

Proposal of AC Magnetic Suspension Using Magnetic Resonant Coupling 491

Takeshi Mizuno, Kei Takahashi, Yuji Ishino, Masaya Takasaki
Saitama University, Japan

Simulation Analysis of Dust-Free Transit System Using Permanent Magnetic Suspension 495

Junjie Jin², Feng Sun², Yingyuan Lu², Koichi Oka¹
¹*Kochi University of Technology, Japan;* ²*Shenyang University of Technology, China*

6D Planar Magnetic Levitation System - Mag6D 499

Christoph Schaeffel¹, Michael Katzschmann¹, Hans-Ulrich Mohr¹, Rainer Gloess²,
Christian Rudolf², Christopher Mock², Carolin Walenda²
¹*Institut für Mikroelektronik- und Mechatronik - Systeme gemeinnützige GmbH, Germany;*
²*Physik Instrumente, Germany*

Materials in Magnetic Bearing Technology

Nd-Fe-B Permanent Magnets for Passive and Hybrid Magnetic Bearings with Extended Application Temperature Range	503
Michael Weickhmann, Matthias Katter, Bernd Schleede <i>Vacuumschmelze GmbH & Co. KG, Germany</i>	
High Strength Iron-Cobalt Materials for Magnetic Bearings	509
Frederik Fohr, Niklas Volbers, Joachim Gerster <i>Vacuumschmelze GmbH & Co. KG, Germany</i>	
Basics of Superconducting Levitation and its Use in the Transport System SupraTrans II	530
Ludwig Schultz ² , Oliver de Haas ¹ , Dietmar Berger ² , Lars Kühn ² , Anne Berger ² , Tilo Espenhahn ² ¹ <i>evico GmbH, Germany</i> ; ² <i>Leibniz-Institut für Festkörper- und Werkstofforschung, Germany</i>	
Superconducting Magnetic Bearings for Industrial Applications	549
Oliver de Haas <i>evico GmbH, Germany</i>	
Recent Development of Soft Magnetic Composite Materials and its Application	561
Lars-Olov Pennander <i>Höganäs AB, Sweden</i>	

Modeling and Identification

Radial Force Modeling for Bearingless Motors Based on Analyze of Field Origins..... 565

Blaise Lapôtre², Nourddine Takorabet², Farid Meilbody-Tabar², Ramdane Lateb¹,
Joaquim Da Silva¹

¹SKF Magnetic Mechatronics, France; ²Université de Lorraine, France

Active Magnetic Bearing Interdisciplinary Design Modelling and Control Tool..... 571

Adam Pilat

AGH University of Science and Technology, Poland

Nitsche-Type Mortaring for Simulation of Electrical Machines 577

Armin Fohler², Walter Zulehner¹

¹Johannes Kepler Universität Linz, Austria; ²Linz Center of Mechatronics GmbH, Austria

Experimental Verification of a Rotor Unbalance Response Based Approach to the Identification of Magnetic Bearing Support Parameters 581

Long Di², Jin Zhou¹, Changli Chen¹, Zongli Lin²

¹Nanjing University of Aeronautics and Astronautics, China; ²University of Virginia, United States

Modeling and Control of Magnetic Bearings with Nonlinear Magnetization..... 587

Ali Gerami², Paul Allaire¹, Roger Fittro²

¹Rotor Bearing Solutions International, LLC, United States; ²University of Virginia, United States

Passive Magnetic Bearings I

Stability Analysis of a New Passive PMs Bearing 593

Ernesto Tripodi, Antonino Musolino, Rocco Rizzo, Dante Casini
Università di Pisa, Italy

Realization of a Multi-Pole Permanent Magnetic Bearing with Rotating Magnetization 599

Edmund Marth, Gerald Jungmayr, Jörg Kobleder, Martin Panholzer, Wolfgang Amrhein
Johannes Kepler Universität Linz, Austria

"Whirl Imposer"--- Proposal for a Novel Passive Magnetic Rotor Bearing System 606

Qingwen Cui¹, Jan Sandtner², Hannes Bleuler¹
¹*École Polytechnique Fédérale de Lausanne, Switzerland*; ²*Silphenix GmbH, Switzerland*

Passive Magnetic Bearings II

Analysis of Passive Magnetic Bearings for Kinetic Energy Storage Systems 611

Elkin Rodriguez², Juan de Santiago⁴, José Pérez-Loya⁴, Felipe Costa², Guilherme Sotelo³, Janaína Oliveira¹, Richard Magdalena Stephan²

¹Universidade Federal de Juiz de Fora, Brazil; ²Universidade Federal do Rio de Janeiro, Brazil; ³Universidade Federal Fluminense, Brazil; ⁴Uppsala University, Sweden

Innovative Magnetic Levitation System by Using Persistent Current in Superconducting Coil..... 616

Mochimitsu Komori, Shingo Takase, Kaoru Nemoto, Nobuo Sakai, Ken-Ichi Asami
Kyushu Institute of Technology, Japan

Experimental Tests and Simulations to the Design of an Electrodynamic Bearing..... 622

Marcelo Lopes¹, Guilherme Sotelo², Elkin Rodriguez¹, Richard Magdalena Stephan¹

¹Universidade Federal do Rio de Janeiro, Brazil; ²Universidade Federal Fluminense, Brazil

Power Electronics for MB

- Design Synthesis and Experimental Validation of an AMB Controller with a Power Dense Amplifier for Retrofit Applications 627**
Praveen Kumar, Richard Jayawant
Waukesha Magnetic Bearings, United Kingdom
- Switch-Mode Current Amplifier for Active Magnetic Bearings 633**
Sergei Basovich, Tomer Ben-Moha, Mor Mordechai Peretz, Shai Arogeti, Ziv Brand
Ben-Gurion University of the Negev, Israel
- Analysis of Nonlinear Behavior in Power Amplifier of AMB System..... 639**
Yin Zhang, Jiancheng Fang, Yinxiao Jiang, Jinxiang Zhou, Qi Chen
Beijing University of Aeronautics and Astronautics / Beihang University, China

Rotor Dynamics

Active Magnetic Bearings as a Tool for Parameter Identification of Journal Bearings 645

Patrick Felscher², Katrin Baumann¹, Oliver Alber²

¹Instrument & Control Systems Engineering GmbH, Germany; ²Technische Universität Darmstadt, Germany

Magnetic Bearing Rotor Vibration Analysis Based on the Harmonic Wavelet Package Algorithm..... 651

Deguang Li, Shuqin Liu

Shandong University, China

A Novel Twin-Shaft Rotor with Active Magnetic Couplings for Vibration Control 655

Chris Lusty, Necip Sahinkaya, Patrick Keogh

University of Bath, United Kingdom

Experimental Modal Analysis of a Gyroscopic Rotor in Active Magnetic Bearings..... 661

Gudrun Mikota¹, Andreas Pröll¹, Siegfried Silber²

¹Johannes Kepler Universität Linz, Austria; ²Linz Center of Mechatronics GmbH, Austria

Identification of Stiffness and Damping via SPHS Excitation and Multi-DOF Active Magnetic Bearing-Rotor Model 665

KeJian Jiang¹, ChangSheng Zhu²

¹Zhejiang Sci-Tech University, China; ²Zhejiang University, China

Self-Sensing Techniques

- Position Estimation for Self-Sensing Magnetic Bearings Based on Double Detection of Current Slopes 673**
Jinou Wang, Andreas Binder
Technische Universität Darmstadt, Germany
- Improved Sensorless Control of a Modular Three Phase Radial Active Magnetic Bearing 679**
Matthias Hofer, Markus Hutterer, Thomas Nenning, Manfred Schrödl
Technische Universität Wien, Austria
- Statistic Errors of Different INFORM Evaluation Methods Applied to Magnetic Bearings 685**
Thomas Nenning, Matthias Hofer, Markus Hutterer, Manfred Schrödl
Technische Universität Wien, Austria
- Setup with Two Self-Sensing Magnetic Bearings Using Differential 3-Active INFORM 689**
Thomas Nenning, Matthias Hofer, Markus Hutterer, Manfred Schrödl
Technische Universität Wien, Austria
- Investigations on the "Direct Digital Inductance Estimation"-Concept for Self-Sensing AMBs Under Influence of Eddy Currents 693**
Michael Richter, Hendrik Schaede, Stephan Rinderknecht
Technische Universität Darmstadt, Germany

Sensor Related Topics I

The Comparison of Excitation Source for Sensors of the AMB System in HTGR..... 699

Xiaohan Liu, Ni Mo, Yan Zhou
Tsinghua University, China

On the Direct Use of Electromagnetic Field Information for Sensorless Rotor Position Control..... 703

Hubert Mitterhofer¹, Mikhail Rakov²
¹*Johannes Kepler Universität Linz, Austria;* ²*RLR Consulting, United States*

Sensor Related Topics II

- Eddy Current Sensors for Magnetic Bearings of the Textile Spinning Machines 709**
Miroslav Stusak
Rieter CZ, Czech Rep.
- Researches on Substrates of High Temperature Eddy Current Sensor 714**
Chao Han², Longxiang Xu², Yingzhe Lin¹
¹*Nanjing CIGU Limited Corporation, China;* ²*Nanjing University of Aeronautics and Astronautics, China*
- Giant Magnetostrictive Material-Fiber Bragg Grating Magnetic Field Sensors Used in Magnetic Bearings 720**
Jiayi Liu, Guoping Ding, Bin Gao, Biyun Zhang
Wuhan University of Technology, China
- Ultra-Thin and Flexible Hall Effect Sensorics 725**
Ingolf Mönch¹, Michael Melzer¹, Falk Bahr², Denys Makarov¹, Wilfried Hofmann², Oliver Schmidt¹
¹*Leibniz-Institut für Festkörper- und Werkstoffforschung, Germany;* ²*Technische Universität Dresden, Germany*
- Effect of Eddy Currents on the Stray Flux Based Measurement System for Magnetic Bearing 733**
Johannes Rudolph, Ralf Werner
Technische Universität Chemnitz, Germany

Special Actuators

Hysteresis Self-Bearing Motor 737

Mohammad Imani-Nejad, David Trumper
Massachusetts Institute of Technology, United States

Magnetically Suspended Reaction Sphere with One-Axis Hysteresis Drive 743

Lei Zhou, Mohammad Imani-Nejad, David Trumper
Massachusetts Institute of Technology, United States

Magnetic Performance of Halbach Array Branching Mechanism Proto-Model Using Cylinder Shaped Permanent Magnets 750

Mikael Braggé², Atsushi Ito¹, Haruhiko Suzuki¹
¹*Fukushima National College of Technology, Japan;* ²*Helsinki Metropolia University of
Applied Sciences, Finland*

Unbalance Handling

- Controller Structure for Magnetic Bearing for Achieving Both Unbalance Suppression and Stabilization 754**
Yuichi Ariga², Yohei Saitoh¹, Keiji Watanabe²
¹Matsue College of Technology, Japan; ²Yamagata University, Japan
- Influence on Unbalanced Magnetic Pull 758**
Henning Kasten, Christian Redemann
Levitec, Germany
- Comparison of a Model-Based and a Model-Free Unbalance Control Methods in Magnetic Bearing System..... 762**
Ying He, Zhe Sun, Jingjing Zhao, Zhengang Shi, Lei Shi
Tsinghua University, China
- Compensation of Unbalance Forces of a Switched Reluctance Machine with Combined Current and Fluxlinkage Control 766**
Thomas Hinterdorfer, Alexander Schulz, Harald Sima, Stefan Hartl, Johann Wassermann
Technische Universität Wien, Austria

Zero Power Control

Zero-Power Control for Magnetic Bearings in Artificial Heart Pumps..... 772
Shuqin Liu, Zhongguo Bian, Youpeng Fan, Yunpeng Zhang
Shandong University, China

**Force Free Control in Active Magnetic Bearing Systems for the Magnetically
Suspended Compound Molecule Pump 776**
Pingfan Liu, Lei Zhao, Ying He, Kai Zhang
Tsinghua University, China

**Structures and Characteristics of Magnetic Bearing with Zero Power Controlled
Electromagnetic Suspension 780**
Yoshitake Kamijo, Hiroaki Ito, Yutaka Maruyama
Toshiba Corporation, Japan