EPFL

École polytechnique fédérale de Lausanne

Local organizer:
Integrated Actuators Laboratory – LAI

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Contents

Welcome Letter

Dear Guests,

We are pleased to welcome you to Neuchâtel – EPFL – Microcity and to the 12th International Symposium on Linear Drives for Industry Applications (LDIA 2019). The goal of the symposium is to bring together researchers from both academia and industry from all over the world, to share research findings and discuss future developments in linear drive technology.

This year, the conference will be held in the EPFL site of Neuchâtel, Microcity. Neuchâtel is a millenary city by a beautiful lake with an incredible view of the entire Alps. The Microcity building was opened in 2013 and 250 researchers within 12 labs from EPFL are doing high level academic research.

Previously, this conference has been hosted in Japan, UK, France, Korea, the Netherlands, China, and Germany. We are convinced that we can make LDIA 2019 to be as successful as the previous ones. We wish you a lot of personal and scientific advancement and to foster your existing network of friends and colleagues. We hope that you enjoy the scientific program with two keynotes and scientific papers from 18 countries.

We would like to thank reviewers and chairpersons for their invaluable assistance in supporting us with the technical program. We also would like to warmly thank the two conference sponsors Sonceboz SA and ETEL SA which will provide high level keynotes of this conference as well as open their doors to the attendees who want to visit them during the last day.

We wish you an enjoyable stay in Neuchâtel as well as a productive and pleasant time at LDIA 2019.

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Prof. Yves Perriard

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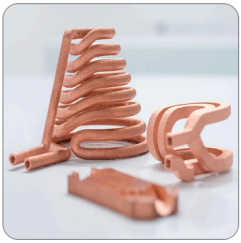
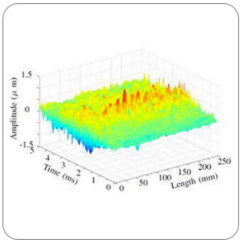
General Information

Integrated Actuators Laboratory (LAI) – LDIA 2019 Local Organizer

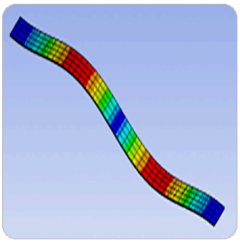
The LAI, part of the Institute of Micro-engineering (IMT), is specialized in modelling and design optimization of rotating and linear electric and piezoelectric motors and actuators. The design optimization is performed using deterministic methods or stochastic ones. The power range is from several kW (electric traction) down to µW (MEMS – batch-processed motor placed on a silicon chip). To miniaturize an electric drive, sensorless control algorithms are applied. A broad set of electromagnetic phenomena are exploited to estimate the rotor/mover position. Among them, two completely new are used: the first one is the magnetic anisotropy of permanent magnet materials (MAM method) and the second is the local B-H hysteresis loops. In the field of piezoelectric actuators, two main axes of research are followed. One axis about the generation of a touch feeling: a piezoelectric actuator generates vibrations of a touch screen so that the user's finger feels a modified friction coefficient when it touches the screen. The second axis about generation of high forces in a reduced volume.



3D-printed coils and motor topology



Multi-touch haptic feedback



Smart gripper based on Shape Memory Alloys

Lab's website: lai.epfl.ch

EPFL Neuchâtel – Micro-engineering Institute (IMT)

At the heart of the Microcity pole of innovation, the Canton of Neuchâtel is hosting an important part of EPFL's Micro-engineering Institute (IMT). This institute's research activities cover topics such as health, microsystems, photovoltaic or watchmaking.

EPFL's researchers are located in the eponymous building of the Microcity pole of innovation. They benefit from the proximity of other research institutions and high-tech manufacturing societies active in micro- and nano-technologies and advanced manufacturing.


© Alain Herzog

The LDIA 2019 Conference will take place in the Microcity building.

Neuchâtel – Cradle of Mirco-engineering and Industrial Center

Renowned for its watch industry, Neuchâtel has been able to position itself as the heart of micro-technology and high-tech industry. During the last 20 years, the Neuchâtel area has attracted many leading companies in the high-tech sectors such as medical technology, micro technology, biotechnology, machines & equipment, IT and clean technologies.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Electricity Service

Switzerland has its own standard which is plug Type J. This plug is similar to C, except that it has the addition of a grounding pin. Voltage is 230 V and frequency is 50 Hz.

Program at a Glance

Welcome Reception


© Nicolas De Nisco

• Monday, July 1st, 17:30 – Hôtel Alpes et Lac

Originally called "Grand Hôtel Terminus", the establishment catered to travellers in search of accommodation. It is ideally located in front of the brand-new Neuchâtel train station while also offering a magnificent view of the lake and the Alps.

Technical Sessions

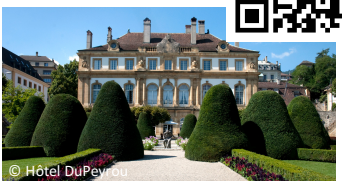
• Tuesday, July 2nd, 2019 – Microcity, Neuchâtel

Invited Talk – Dr. Christophe Espanet, Scientific Director – Sonceboz Group
Sessions are starting at 09:00 and ending at 17:00

• Wednesday, July 3rd 2019 – Microcity, Neuchâtel

Invited Talk – Dr.-Ing. Michael van der Giet, Marketing and Sales Director – ETEL SA
Sessions are starting at 09:00 and ending at 17:00

Gala Dinner


© Hôtel DuPeyrou

• Tuesday, July 2nd, 18:30 – Hôtel DuPeyrou

The traditional LDIA Conference Gala Dinner will be served in the Hôtel Dupeyrou, a house situated in the heart of Neuchâtel that dates back to the 18th-century. This gem of Neuchâtel architecture houses a renowned gourmet restaurant.

Technical Visits (on reservation)

Thursday, July 4th, from 09:00 to 17:00 – ETEL SA and Sonceboz Group

Meeting point in front of Microcity building, main entrance A – Departure at 09:00.


© ETEL SA - BNJ


© Sonceboz Group

Monday, July 1st

09:00

10:00

11:00

12:00

13:00 - 16:30	Registration *(Microcity Main Hall)*

17:00

17:30 - 19:00	Welcome Reception & Registration *(Hôtel Alpes et Lac)*

20:00

21:00

Tuesday, July 2nd

08:00 - 17:00	Registration	
09:00 - 09:15	Opening Ceremony	
09:15 - 10:00	Talk by Dr. Ch. Espanet - Sonceboz	
10:00 - 11:00	Session Tu1.A *Topic 1*	Session Tu1.B *Topic 4*
11:00 - 11:20	Coffee Break	
11:20 - 12:40	Session Tu2.A *Topic 1*	Session Tu2.B *Topic 6*
12:40 - 14:00	Lunch *(4th Floor)*	
14:00 - 15:00	Session Tu3.A *Topic 1*	Session Tu3.B *Topic 8*
15:00 - 16:00	Coffee Break & Poster Session Tu4.H	
16:00 - 17:00	Session Tu5.A *Topic 2*	Session Tu5.B *Topic 6*

18:30 - 21:30	Gala Dinner *(Hôtel DuPeyrou)*

Wednesday, July 3rd

08:00 - 17:00	Registration	
09:00 - 09:45	Talk by Dr. M. van der Giet - ETEL	
09:50 - 10:50	Session We1.A *Topic 1*	Session We1.B *Topic 6*
10:50 - 11:10	Coffee Break	
11:10 - 12:30	Session We2.A *Topic 1*	Session We2.B *Topic 3*
12:30 - 13:50	Lunch *(4th Floor)*	
13:50 - 15:10	Session We3.A *Topic 1*	Session We3.B *Topic 3*
15:10 - 15:30	Coffee Break	
15:30 - 16:30	Session We4.A *Topic 1*	Session We4.B *Topic 6*
16:30 - 17:00	Closing & Award Ceremony	

Thursday, July 4th

09:00 - 09:50	Neuchâtel - Môtiers
10:00 - 12:00	Technical Visit ETEL SA
12:10 - 13:50	Môtier - Sonceboz (lunch included)
14:00 - 16:00	Technical Visit Sonceboz Group
16:10 - 17:00	Sonceboz - Neuchâtel

Topic 1	Electromagnetic linear motors and actuators
Topic 2	Non-electromagnetic linear motors and actuators
Topic 3	Control methods for linear drives
Topic 4	Levitation technologies
Topic 5	Subsystems for linear drives
Topic 6	Applications of linear drives and levitation tech.
Topic 7	Analysis of electromagnetic fields and force fields
Topic 8	Materials & Other topics

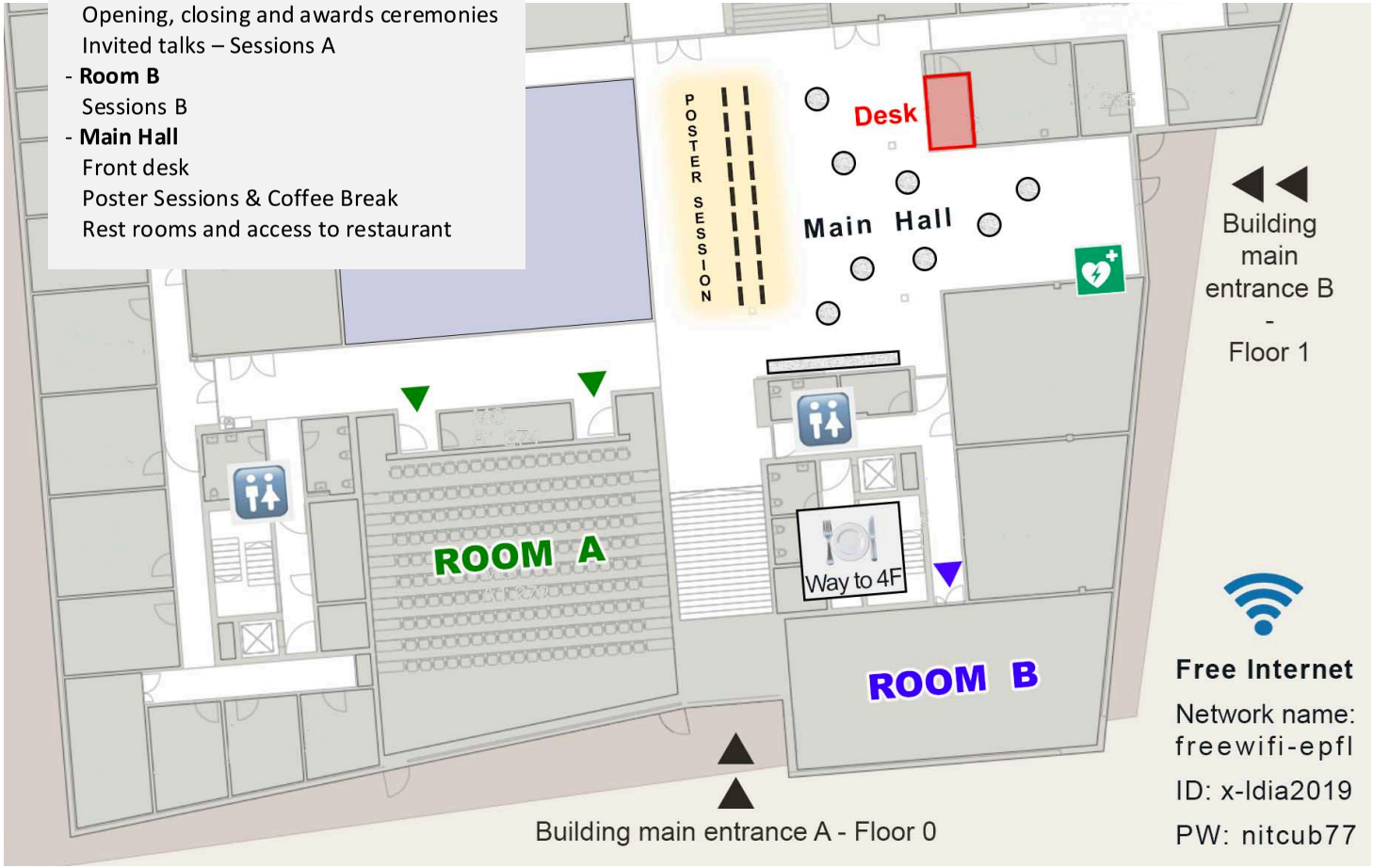
Rooms usage	
Room A	Ceremonies
	Invited talks
	xxxx.A sessions
Room B	xxxx.B sessions
Main Hall	Registration
	Coffee Break
	Poster session

Venue Layout

Neuchâtel

Conference Site Map

- **Room A**
  Opening, closing and awards ceremonies
  Invited talks – Sessions A
- **Room B**
  Sessions B
- **Main Hall**
  Front desk
  Poster Sessions & Coffee Break
  Rest rooms and access to restaurant



Presentations - Tuesday, July 2nd, 2019

Invited Talk – Dr. Christophe Espanet, Scientific Director, Sonceboz Group

Time: 09:15 – 10:00 Room A

Session chair: Prof. Elena Lomonova

Linear Drives in Sonceboz Group: Technologies and Applications

Short Bio

Since 2014, Christophe Espanet is the Scientific Director of Sonceboz Group, Switzerland, and he is in charge of the advanced research, the technology roadmap and the academic partnership of the Group. Previously, from 1999 to 2014, he was successively Associate Professor and Full Professor in the University of Franche-Comte, Belfort, France. His research interests included the modelling and the design of electrical systems and in particular electric machines.

Christophe Espanet received the Bachelor degree and the Master degree in applied physics from the University of Paris, France, respectively in 1992 and 1993. He received the Ph.D. degree from the University of Franche-Comte in 1999.

He has published about 100 academic publications in leading international conferences and journals. He has been Technical Chair of IEEE VPPC (Vehicle Power Propulsion Conference) in 2010 (Lille, France) and in 2014 (Coimbra, Portugal).

Abstract

Since 1936, Sonceboz develops and produces high quality mechatronic systems designed for positioning, flow control and traction. The systems are based on electric motors and mechatronic drive systems with linear or rotary movement for harsh or

hostile environments. Thanks to a very high level of industrial automation and a strong level of control at each stage of the production, Sonceboz is able to provide mechatronic solutions for mass production with a very high level of reliability.

In this keynote, Sonceboz will present a focus on the linear actuators. In a first part, solutions with both rotating motors and mechanical transformations are presented. This kind of solution is strongly used in different Sonceboz products, in automotive positioning applications (idle air control valve, water valve, EGR valve, turbo bypass) as well as in truck and off-road applications (mobile hydraulic for agricultural systems). In the presented applications, the stroke varies from few millimeters to few centimeters with ten micrometers resolution and the force varies from tens of newtons to hundreds of newtons. The motor and mechanical transformation technologies will be described, with special highlights on the motor topologies and the mechanical transformation integration.

In a second part, direct drive actuators are presented. The main advantage is to increase the mover speed since no mechanical transformation need to be driven. In that context, two applications dedicated to ICE efficiency improvement will be detailed. The first one is a direct drive linear bistable actuator which is used to shift camshafts of various groove distances for cylinder deactivation or discrete variable valve lift applications. This improves the engine's performance and reduces CO2 emissions. The second one concerns an electromagnetic valve, which is an ultimate solution to refine the control of the opening and closing of ICE valves.

Finally, in conclusion of this keynote, following the presentation of existing actuators, several issues for linear drive improvement will be drawn and associated topics of research will be proposed.

Session Tu1.A - Topic 1: Electromagnetic linear motors and actuators

Time: 10:00 – 11:00 Room A

Session chair: Prof. Jeong Seo Koo

1. Modeling of Integrated Eddy Current Damping Rings for a Tubular Electromagnetic Suspension System

Friedrich, L.A.J.; Gysen, B.L.J.; Lomonova, E.A.

Eindhoven University of Technology, The Netherlands

2. A High Force Density Linear Actuator for Active Suspension

Liu, zhengmeng; Wang, jiabin

University of Sheffield, United Kingdom

3. Design of a permanent magnet-biased reluctance valve actuator with integrated eddy current damping

van Dam, J.R.M.; Gysen, B.L.J.; Lomonova, E.A.

Eindhoven University of Technology, The Netherlands

Session Tu1.B - Topic 4: Levitation technologies

Time: 10:00 – 11:00 Room B

Session chair: Prof. Haruhiko Suzuki

1. Non-contact Conveyance Experiments for a Steel Plate under Levitation and Guidance Control without using Gap Sensors and Sideslip Sensors

Harigaya, Nao; Oikawa, Ikuto; Nakagawa, Toshiko

Tokyo City University, Japan

2. Experimental Confirmation of Speed and Air Gap Control with Only Linear Induction Motor for Levitation

Nakatani, Shota; Sannomiya, Kenta; Okamori, Daichi; Morizane, Toshimitsu; Kimura, Noriyuki; Omori, Hideki

Osaka Institute of Technology, Japan

3. Three-Dimensional Control of an Iron Ball by Flux-path Control Mechanisms Located around Magnetic Source

Mizuno, Takeshi; Ishibashi, Naoki; Ishino, Yuji; Takasaki, Masaya; Yamaguchi, Daisuke

Saitama University, Japan

Session Tu2.A - Topic 1: Electromagnetic linear motors and actuators

Time: 11:20 – 11:40 Room A

Session chair: Prof. Ke Wang

1. Performance Measurement of an Electromagnetic Free Piston Compressor without Permanent Magnets

Rafetseder, David; Amrhein, Wolfgang

Johannes Kepler University Linz, Austria

2. Linear Generator Design for a Free-Piston Engine with high Force Density

Schillingmann, Henning; Maurus, Quirin; Henke, Markus

Technische Universität Braunschweig, Germany

3. Examination of a Free-piston Engine Linear Generator System with Opposite-side Combustion

Suzuki, Tatsuki (1); Naganuma, Kaname (2); Nirei, Masami (3); Sato, Mitsuhide (1,4); Yamanaka, Yuichiro (1); Goto, Takumi (1); Yinggang, Bu (1); Mizuno, Tsutomu (1)

1: Shinshu University, Japan; 2: Kanazawa Institute of Technology, Japan; 3: National Institute of Technology, Nagano College, Japan; 4: Nagano Prefectural Institute of Technology, Japan

4. A study of translator length in a tubular linear electrical machine designed for use in a linear combustion joule engine

Moeini Korbekandi, Ramin; Baker, Nick; Wu, Dawei

Newcastle University, United Kingdom

Session Tu2.B - Topic 6: Applications of linear drives - Levitation techniques

Time: 11:20 – 11:40 Room B

Session chair: Prof. Takafumi Koseki

1. A Review of Integrated Propulsion, Suspension and Guidance Passive Guideway Maglev Technologies

Bird, Jonathan

Portland State University, United States of America

2. Modified H-LSM for urban MAGLEVs

Boldea, Ion (1,2); Tutelea, Lucian Nicolae (1,2); Xiao, Xinyu (3); Torac, Ileana (2); Pucci, Marcello (4); Xu, Wei (3)

1: Politehnica University of Timisoara, Romana; 2: Romanian Academy - Timisoara Branch; 3: Huazhong University of Science and Technology, People's Republic of China; 4: Italian National Research Council, Italy

3. A Low-speed Maglev Speed Increasing Plan by Adopting 3000V DC Power Supply

Wang, Xiaohua; Lin, Ying; Lu, Diqiang

Tonji University, People's Republic of China

4. A New Concept Structure of the Propulsion System for a Medium Speed Maglev System – Simulation and Analysis

Lin, Ying; Lu, Diqiang; Qin, Feng; Wang, Xiaohua; Jin, Yu

Tongji University, People's Republic of China

Session Tu3.A - Topic 1: Electromagnetic linear motors and actuators

Time: 14:00 – 15:00 Room A

Session chair: Prof. Antonino Musolino

1. Trends in Superconducting Linear Electric Machines

Bianchetti, Marco; Krop, Dave; Lomonova, Elena

Eindhoven University of Technology, The Netherlands

2. Tunnel-Vision on Economic Linear Propulsion?

Veltman, André (1); van der Hulst, Paul (1); Jonker, Marco (2); Polinder, Henk (3)

1: Piak Electronic Design B.V., The Netherlands; 2: Engie Electroproject B.V., The Netherlands; 3: Delft University of Technology, The Netherlands

3. Proposal of a Novel Transfer Device Using a Linear Motor in Parallel Synchronous Operation

Yoshida, Kengo; Suzuki, Kenji; Dohmeki, Hideo

Tokyo City University, Japan

Session Tu3.B - Topic 8: Materials and other topics

Time: 14:00 – 15:00 Room B

Session chair: Prof. Jianxin Shen

1. Slide performance of magnetic field distribution by using cylinder-shaped PM type linear Halbach array with synchronized rotation mechanism

Suzuki, Haruhiko; Itasaka, Toshiki; Ishiguro, Yuki; Shinosaki, Kouta; Watanabe, Jun; Wakamatsu, Daichi; Ito, Atsushi

National Institute of Technology, Fukushima College, Japan

2. Investigation of magnetic performance on the cylinder-shaped PM type linear Halbach array assembled by 45 degree rotating arrangement

Itasaka, Toshiki; Ishiguro, Yuki; Shinosaki, Kota; Watanabe, Jun; Wakamatsu, Daichi; Ito, Atsushi; Suzuki, Haruhiko

National Institute of Technology, Fukushima College, Japan

3. Characteristics Investigation of Linear Eddy-Current Brake Based on HALBACH Magnet Array for Transport System

Gong, Jun; zhang, zhihua; Zhang, Yanqing; Zhai, Maochun; Zhou, Wei; Liu, Kun

Institute of Magnetic Levitation and Electromagnetic Propulsion, People's Republic of China

Poster sessions on Tuesday, July 2nd, 2019 – Microcity Main Hall

Poster Session Tu4.H

Time: 15:00 – 16:00 Main Hall

Session chair: Prof. Pierre-Daniel Pfister

P1. A L1B4 Piezoelectric Ultrasonic Linear Micromotor Using a Full Symmetry Stator
Li, Chaodong
Shanghai University, People's Republic of China

P2. Bearing-less four-coil oscillatory linear motor
Poltschak, Florian G.
Johannes Kepler University Linz, Austria

P3. Noncontact MC type Rotary Motor Using Lorentz Force and Wireless Power Supply
Oka, Koichi; Oguri, Yuto; Kajisawa, Yusuke; Harada, Akinori
Kochi University of Technology, Japan

P4. Mathematical Analysis of Novel Conical Hybrid Magnetic Bearing for Six Degrees of Freedom Control System
Roshanzamir, Ali; Kwon, Byung-il
Hanyang university, Republic of South Korea

P5. Influence of eddy current losses in the optimization of linear coreless BLDC motors with PCB windings
François, Guillaume; Baudart, François; Dehez, Bruno
Université Catholique de Louvain, Belgium

P6. Analysis of an Electromagnetic Railgun with Tapered Rails and Concave Armature using 3-D FEM
Suri, Rama Naga Praneeth; Singh, Bhim; Chaudhuri, Dipta; Bhuvaneswari, G; Chatterjee, Shouri
Indian Institute of Technology, Delhi, India

P7. Improved modelling of a monomorph piezoelectric actuator for linear self-sensing applications
Masson, Louis Antoine; Perriard, Yves
École polytechnique fédérale de Lausanne (EPFL), Switzerland

P8. Design of Double Sided Linear Motor with Easy to Manufacture Hairpin Plate Winding
Çakal, Gökhan; Keysan, Ozan
Middle East Technical University, Turkey

P9. A Rotor Posture Measurement System by Analyzing Sensed Magnetic Field from Arrayed Hall Sensors
Gofuku, Akio (1); Yokomitsu, Naoto (1); Yano, Tomoaki (2); Kasashima, Nagayoshi (3)
1: Okayama University, Japan; 2: Japan Aerospace Exploration Agency, Japan; 3: National Institute of Advanced Industrial Science and Technology, Japan

P10. Design Principle for Linear Electrical Machines to Minimize Power Loss in Periodic Motions
Benecke, Sebastian; Gerlach, Andreas; Leidhold, Roberto
Otto-von-Guericke-University Magdeburg, Germany

P11. Investigation of Linear Generator for High Speed Maglev Train by 2D Finite Element Model
Li, Longxiang; Lu, Qinfen
Zhejiang University, People's Republic of China

P12. Investigation on Double-Sided Linear Fluxswitching Permanent Magnet Motors with NoneOverlapping Windings
Lu, Minghang; Cao, Ruiwu
Nanjing University of Aeronautics and Astronautics, People's Republic of China

P13. The Influence of the Secondary Thickness on the Air-Gap Magnetic Felid and Losses of the Linear Induction Motor
Lyu, Gang; Zhou, Tong; Zeng, Dihui
Beijing Jiaotong University, Beijing, People's Republic of China

Session Tu5.A - Topic 2: Non-electromagnetic linear motors and actuators

Time: 16:00 – 17:00 Room A

Session chair: Prof. Wei Xu

1. Linear Actuator Utilizing Magnetic Shape Memory Material

Tüysüz, Arda; Breisch, Sebastian; Molter, Tim

ABB AG, Germany

2. Design Analysis of a Shape Memory Alloy Bias-Spring Linear Actuator

Thomas, Sean; Almanza, Morgan; Perriard, Yves

École polytechnique fédérale de Lausanne (EPFL), Switzerland

3. Multi-objective optimisation methodology for self-sensing piezoelectric monomorph benders

Masson, Louis Antoine; Perriard, Yves

École polytechnique fédérale de Lausanne (EPFL), Switzerland

Session Tu5.B - Topic 6: Applications of linear drives - Levitation techniques

Time: 16:00 – 17:00 Room B

Session chair: Prof. Liming Shi

1. Development of a Linear Motor for Urban Magnetically Levitated Vehicles Using an Innovative Workbench Topology

Oliveira, Roberto André Henrique de; Stephan, Richard Magdalena; Ferreira, Antonio Carlos; Murta Pina, João

Federal University of Rio de Janeiro, Brazil

2. Technical Efforts for Energy-Saving Operation of Linear Metros in Japan

Koseki, Takafumi (1); Miyoshi, Shota (1); Watanabe, Shoichiro (1,2); Isobe, Eisuke (3); Mizuma, Takesi (1)

1: The University of Tokyo, Japan; 2: National Traffic Safety and Environment Laboratory, Japan; 3: Japan Subway Association, Japan

3. Dynamic Analysis of a Tubular Generator for Automotive Suspension Applications

Kleijer, M.; Friedrich, L.A.J.; Gysen, B.L.J.; Lomonova, E.A.

Eindhoven University of Technology, The Netherlands

Presentations - Wednesday, July 3rd, 2019

Invited Talk – Dr.-Ing. Michael van der Giet, Sales and Marketing Director, ETEL SA, Switzerland

Time: 09:00 – 09:45 Room A

Session chair: Dr. Alain Cassat

Application of high performances direct drives in motion systems for the semiconductor and electronics equipment market

Short Bio

Since 2017, Michael van der Giet is Sales and Marketing Director at ETEL SA, Switzerland. From 2011 to 2017 he was head of the R&D department of electrical motors at Dr.-Johannes-Heidenhain GmbH, Traunreut, Germany. There, he was working on the development of modern permanent magnet excited synchronous motors as axis drives and high-speed induction machines for the main spindles, both for machine tool applications.

In 2011 he received his PhD in electrical engineering from the RWTH Aachen University, Germany. His research was focused on the electromagnetic excitation that lead to audible noise of rotating electrical machines. In 2004 he received his Master of Science degree in electrical engineering from the RWTH Aachen University, Germany.

Abstract

Since its founding in 1974, ETEL has been dedicated to the development of direct drive linear motor technology. Through numerous innovations and patented designs, ETEL continues to provide unmatched force efficiency for the most optimized designs. In the early 80ies the same concept of direct drive technology was extended to rotary motors, which led to the invention of the torque motor, applied for telescopes first and later extensively adopted by the machine tool industry. After introducing unique motor technologies in the market ETEL developed controllers with the scope of reaching the best possible motion performance in demanding applications such as semiconductor and electronics markets. In the following years, the “forward integration” led ETEL to

become a key player in the motion system market by developing a variety of standard products targeting down to the nanometer level.

This keynote is shedding light on the specific needs of the semiconductor and electronics equipment market in terms of motion system, mainly focusing on process control and assembly equipment. The main concern is oriented around two central elements: 1. Accuracy and 2. Throughput. The key challenge that is solved by the complete ETEL motion solution is to be able to perform both at the same time.

A bright example of typical requirements of the semiconductor front-end, and of delivered performance, comes with ETEL high end mechanical bearing based motion system. With 6 degrees of freedom (DOF), it runs at 2.5g acceleration and 1.5 m/s speed, while guaranteeing a 500-nm repeatability in positioning accuracy and less than 5 nm jitter at the tool point. On top of the base xy-motion system, several modular options for rotation and z-actuation of the wafer are part of ETEL's offering, also the patented compact design of a Z actuator with an adjustable gravity compensation and negative stiffness. The technical details of this actuator are presented in a separate paper during the conference.

Most of the time, high-end applications in the semiconductor industry integrate complex equipment set-up, which, in one way or another, is connected to the granite of the motion platform. Some of those applications have stringent position stability requirements at the stage level, down to the nanometer range! Any vibration at the granite level therefore translates into inaccuracies and longer settling times at the process tool level. The QuiET active isolation system is a new module cancelling both stage-born and ground-born vibrations along 6 DOF, preventing them from disturbing the process taking place on top of your motion platform. With an acceleration feedforward accuracy reaching more than 99%, less than 1% of the energy generated by a motion stage movement remains at the granite level!

Another example, highlighted in this key note is ETEL’s force control feature, which is specifically designed to maximize throughput and precisely manage the contact force of diverse motion axes in the semiconductor back-end. The main benefits are such as: zero stop time, sensorless capability, and precise force control in sub-newton range.

Also, targeting the semiconductor back-end market, ETEL will present its new-born high-end dual gantry positioning system equipped with water cooled linear motors and a specific metrology equipment (Moving Metrology Frame) allowing ±1 µm positioning accuracy at the tool point while running at extremely high dynamics. Acceleration up to 80 m/s^2 can be reached. This platform perfectly fits the next generation die bonding requirements for Fan-Out packages on wafer and large panel substrates (up to 720 mm x 650 mm) while reducing overall costs of ownership.

Session We1.A - Topic 1: Electromagnetic linear motors and actuators

Time: 09:50 – 10:50 Room A

Session chair: Prof. Jiabin Wang

1. Rapid co-kriging based multi-fidelity surrogate assisted performance optimization of a transverse flux PMLSM

Ahmed, Salman (1); Koseki, Takafumi (1); Norizuki, Kunihiko (2); Aoyama, Yasuaki (2)

1: The University of Tokyo, Japan; 2: Hitachi, Ltd, Japan

2. Electric drive train design for wave energy converters

Baker, Nick; Rahan, M; Almoraya, A; McDonald, S

Newcastle University, United Kingdom

3. Comparison Analysis of Cylindrical and Rectangular Linear Permanent Magnet Transverse-Flux Machines for Wave Energy Applications

Dobzhanskyi, Oleksandr

Oregon Institute of Technology, United States of America

Session We1.B - Topic 6: Applications of linear drives - Levitation techniques

Time: 09:50 – 10:50 Room B

Session chair: Prof. Koichi Oka

1. Application and Validation of a Linear Electromagnetic Actuator within a Haptic Piano Key

Timmermans, Sébastien; Fisette, Paul; Dehez, Bruno

Université Catholique de Louvain, Belgium

2. Control of the Lateral Vibration by using Weight Reduced Damper Coil on Superconducting Magnetically Levitation Bogie

Ohashi, Shunsuke; Nakakita, Riki; Takeuchi, Tomohiro

Kansai University, Japan

3. Design of a Linear Permanent Magnet Transverse Flux Motor for Needle-free Jet Injection

Do, Nick N. L.; Taberner, Andrew J.; Ruddy, Bryan P.

The University of Auckland, New Zealand

Session We2.A - Topic 1: Electromagnetic linear motors and actuators

Time: 11:10 – 12:30 Room A

Session chair: Prof. Jacek Francis Gieras

1. Design and Analysis of Surface Permanent Magnet Vernier Linear Motor Based on Air Gap Magnetic Flux Density Distribution

Shi, Hyoseok; Niguchi, Noboru; Hirata, Katsuhiro

Osaka University, Japan

2. Comparison of Toroidal-Winding Linear PM Vernier Machines with Typical Linear Synchronous Machines in Aspect of Thrust Force Characteristics

Zhang, He

Harbin Institute of Technology, People's Republic of China

3. Design and Simulation of a Double-Mover Tubular Linear Induction Motor for High Thrust Force

Musolino, Antonino; Rizzo, Rocco; Sani, Luca; Consolo, Valentina; Simonelli, Claudia

University of Pisa, Italy

4. A Magnetic Lead Screw with Variable Stiffness Mechanism

Heya, Akira; Nakata, Yoshihiro; Hirata, Katasuhiro; Ishiguro, Hiroshi

Osaka University, Japan

Session We2.B - Topic 3: Control methods for linear drives

Time: 11:10 – 12:30 Room B

Session chair: Prof. Rainer Hagl

1. Sensorless Control of a Linear Generator for Energy Harvesting Applications

Bodrov, Alexey; Zhang, Min; Shuttleworth, Roger; Iacchetti, Matteo Felice

The University of Manchester, United Kingdom

2. Sensorless Direct Thrust Control of a Linear Induction Motor Based on MRAS

Elmorshedy, Mahmoud Fouad (1,2); Xu, Wei (1); Liu, Yi (1); Ali, Mosaad (1,3)

1: Huazhong University of Science and Technology, People's Republic of China; 2: Tanta University, Egypt; 3: Kafrelsheikh University, Egypt

3. Verification of Effectiveness of an MRF SemiActive Damper using a Double-Cage Structure Elevator Simulator

Torii, Takeshi; Kawase, Keisuke; Nakagawa, Toshiko

Tokyo City University, Japan

4. Winding layout for active bearing force reduction in tubular linear motors

Poltschak, Florian G.; Thalhammer, Richard

Johannes Kepler University Linz, Austria

Session We3.A - Topic 1: Electromagnetic linear motors and actuators

Time: 13:50 – 15:10 Room A

Session chair: Prof. Shunsuke Ohashi

1. Design of a High-Temperature Linear Electromagnetic Actuator

Gieras, Jacek Francis

University of Technology and Life Sciences, Poland

2. Experimental Study of Thermal Behavior of Tubular Linear Machines

Lawali, Habibou (1); Amara, Yacine (1); Peixinho, Jorge (1); Barakat, Georges (1); Ziegler, Nicolas (2)

1: Université Le Havre Normandie, France; 2: ERENO, France

3. Multiphysics Analysis of Tubular Linear Permanent Magnet Synchronous Motor Operating Immersed in Crude Oil

Wu, Yi Chen; Cirolini, Mateus; Ziemniczak, Aline; Hayashi, Thamy Cristina; Perondi, Eduardo Andre; Eckert, Paulo Roberto

Federal University of Rio Grande do Sul, Brazil

4. Multifunctional Z Actuator with an Adjustable Built-in Gravity Compensator For High Precision Systems

Mittal, Manish; Tamellini, Valerio; Fasolo, Alessandro; Galdos, Gorka; Szczukiewicz, Sylwia

ETEL S.A., Switzerland

Session We3.B - Topic 3: Control methods for linear drives

Time: 13:50 – 15:10 Room B

Session chair: Prof. Toshimitsu Morizane

1. A Proposal for Precison Positioning Control of Linear Induction Motor Using Nonlinear Friction Compensation and High-Order Disturbance Observer

Egashira, Shunya (1); Nakagawa, Toshiko (2)

1: Tokyo City University Graduate Division, Japan; 2: Tokyo City University, Japan

2. Wave Force Simulation of Direct Drive Wave Energy Conversion System Based on SRM

Yang, Kun; Du, Jinhua; Liu, Quanwei

Xi`an Jiaotong University, People's Republic of China

3. Traction Control of Multi-section Long Primary Ironless Linear Synchronous Motor for Maglev Vehicle

Wang, Ke; Deng, Zhuoyuan; Ge, Qiongxuan; Shi, Liming; Li, Yaohua

Chinese Academy of Sciences, People's Republic of China

4. Bandwidth Improvements of Linear Direct Drives with a 100 kHz PWM-Frequency

Hoellthaler, Julia (1); Hagl, Rainer (1); Kennel, Ralph (2)

1: Technical University of Applied Sciences Rosenheim, Germany; 2: Technical University of Munich, Germany

Session We4.A - Topic 1: Electromagnetic linear motors and actuators

Time: 15:30 – 16:30 Room A

Session chair: Prof. Pierre-Daniel Pfister

1. Design and Comparison of Permanent Magnet Self-Bearing Linear-Rotary Actuators

Miric, Spasoje; Bortis, Dominik; Kolar, Johann Walter

ETH Zurich, Switzerland

2. The Multi-Objective Optimization of Ironless Permanent Magnet Linear Synchronous Machine with Unequal Halbach Array

Wang, Huihuang (1,2); Du, Yumei (1,2); Shi, Liming (1); Zhang, Ruihua (1)

1: Chinese Academy of Sciences, People's Republic of China; 2: University of Chinese Academy of Sciences, People's Republic of China

3. Analysis of End Pole Sizing Effects in Linear Permanent Magnet Synchronous Actuators with quasi-Halbach Arrays

Boff, Ben Hur Bandeira; Tavares, Rodrigo Borges; Flores Filho, Aly Ferreira; Eckert, Paulo Roberto

Federal University of Rio Grande do Sul, Brazil

Session We4.B - Topic 6: Applications of linear drives - Levitation techniques

Time: 15:30 – 16:30 Room B

Session chair: Prof. Takeshi Mizuno

1. Inclination control of the carrier in the magnetically levitated conveyance system using the linear stepper motor

Ito, Kota; Yoshida, Junichiro; Watano, Ibuki; Ohashi, Shunsuke

Kansai University, Japan

2. Global Optimization Design of a Linear Oscillating Motor Based on Kriging Surrogate Model

Bu, Lixiao; Du, Jinhua

Xi'an Jiao Tong University, People's Republic of China

3. Basic Characteristics of the Yoke Equipped Rotors in the Magnetic Bearing using HTS Pinning Effect

Takimura, Satoshi; Arai, Tomoaki; Hiraoka, Shota; Ohashi, Shunsuke

Kansai University, Japan

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