



**11 - 14 August 2017, ICC Sydney, NSW, Australia**

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**The 20<sup>th</sup> International Conference on Electrical Machines and Systems (ICEMS2017)**

**Tutorial One**

**Design, Modelling and Control of Linear Induction Motors (LIM)  
for Industrial Applications**

- Time and Date:** 13:45 – 17:00 on Friday 11 August 2017
- Venue:** Building 11, University of Technology Sydney)
- Tutors:** Prof. Wei Xu, SMIEEE  
School of Electrical and Electronics Engineering  
Huazhong University of Science and Technology (HUST), China
- Dr. Marcello Pucci  
Institute of Intelligent Systems for the Automation (ISSIA)  
National Research Council of Italy (CNR), Italy
- Prof. Ion Boldea  
Department of Electrical Machines and Drives  
University Politehnica of Timisoara (UPT), Romania

**Abstract**

The main subject of the tutorial is linear induction motors (LIMs). Starting from a brief structural description of such motors, their main applications will be exposed in the tutorial with specific reference to MAGLEV (Magnetically Levitation) vehicles, urban people movers (such as linear metro, light railway, *etc.*), X-Y planar motion industrial platforms, launchers, actuators for industry and automotive. As a first step, the main differences between rotating and linear induction motors will be highlighted, focusing on the aspects of static and dynamic end effects as well as transversal edge effects. The typical structure of LIMs will be treated, with specific reference to secondary sheet and primary winding configurations. Single-sided LIMs (S-LIMs) and Double-sided ones (D-LIMs) will be described in details, focusing on normal force effects. Design criteria of LIMs will be specifically exposed, emphasizing the main differences with the classic rotating induction motor design, caused by the presence of large air-gaps, high leakage inductances as well as the end effects. Both static and dynamic models of LIMs will be introduced, including the so called end-effects, magnetic saturation, non-linear traits influenced by PWM modulation, and so on. Suitable parameter estimation methods will be then described. Afterwards, control techniques specifically devised for LIMs, like field oriented control, input-output feedback linearization control, active disturbance rejection control, model predictive control, efficiency optimization control, *etc.*, will be introduced in details. Finally, sensorless techniques with strong robustness capability specifically developed for LIMs will be shown.

## The intended audience

The tutorial is likely to be of interest to university researchers, scientists, professionals, skilled engineers, and graduate students, *et al*, who wish to learn the advancements in the new linear machine topologies, integrated modelling, multi-objective optimization techniques, and high performance control strategies and its emerging applications in transportation and energy conversion systems. The potential audience should have some knowledge or background about electrical machine and drive system, energy conversion system, control theory, power electronics, mechanical system, and so on. Audience from electrical, mechanical and information engineering fields may also find this tutorial useful when dealing with transportation motor and drive related design, optimization and control development, mechanical design and analysis, and so on.

## Tutor Biographies

**Prof. Wei Xu** received the double B.E. degree from Tianjin University (TJU), China, in July 2002, and M.E. degree from TJU in March 2005, and the Ph.D. degree from Institute of Electrical Engineering, Chinese Academy of Sciences (IEECAS), in July 2008, respectively, all in electrical engineering. From 2008 to 2013, he held several academic positions in both Australian and Japanese Universities and Companies. Since 2013, he has been appointed as Full Professor with Huazhong University of Science and Technology (HUST), China. Now he is leading one research group, Center for Energy Conversion System (CECS), including 3 staff and more than 30 PhD/ME students, for the development on high performance of electrical machines (particularly linear machines) and drive systems based on transportation (electrical vehicle, urban railway, *etc.*), wind generation, servo, and so on. In the aforementioned field, Prof. Xu has accepted or published about 200 technique papers (more than 60 International Journal papers), held 50 granted or pending patents, edited 2 books in cooperation with Springer Press (one published in 2016, another in 2018).

Prof. Xu is one IEEE Senior Member (2013), and will be awarded as IET Fellow in 2018. Since 2014, He has been invited to make four-time Keynote Speaking in International Conferences by the field of Electrical Machines and Drive Systems. Meanwhile, as one Guest Editor, Prof. Xu has been invited to organize three-time Special Issues in peer review high-quality Journals, such as one Special Issue titled by Design and Control for Linear Machines, Drives, and MAGLEVs in IEEE Transactions on Industrial Electronics (2018).

Prof. Xu had been invited to serve as one Senior Consultant Engineer for new structure axial flux permanent magnet machine with Axiflux Pty Ltd, Australia from 2011 to 2012, and develop on high performance PMSM machine in Meiji University, Japan in 2012. Since 2015, he has been invited to serve as one consultant technique technical director for China Changjiang National Shipping Group Motor Factory.

Prof. Xu has been awarded as Vice Chancellor Research Fellow with RMIT University (Australia, 2010), Invitation Japan Society for the Promotion of Science (JSPS) Research Fellow (2011), China 1000-Youth Talent (2015).

**Dr. Marcello Pucci** received his 'laurea' degree in Electrical Engineering from the University of Palermo (Italy) in 1997 and the Ph.D. degree in Electrical Engineering in 2002 from the same University. In 2000 he has been one host student at the Institute of Automatic Control of the Technical University of Braunschweig, Germany, working in the field of control of AC machines, with a grant from DAAD (Deutscher Akademischer Austauschdienst – German Academic Exchange Service). From 2001 to 2007, he has been a researcher, and since 2008 he has been a senior

researcher at the Section of Palermo of I.S.S.I.A.-C.N.R. (Institute on Intelligent Systems for the Automation), Italy.

Dr. Pucci has served as an associate editor of the IEEE Transactions on Industrial Electronics and IEEE Transactions on Industry Applications. He is a member of the Editorial Board of the 'Journal of Electrical Systems'. His current research interests are electrical machines, control, diagnosis and identification techniques of electrical drives, intelligent control and power converters.

**Prof. Ion Boldea** was elected as one IEEE Fellow in 1996, and has been one IEEE Life Fellow since 2011. He received his M.S. and Ph.D. degrees in 1967, respectively, 1973, from the University Politehnica of Timisoara, Romania, where he is a Full Professor. He spent about 5 years in all as Visiting Professor in Electrical Engineering in USA (in Kentucky and Oregon) since 1973, when he was a Senior Fullbright Scholar for 10 months. He was a Visiting Professor in UK at UMIST and Glasgow University for a few times. Prof. Boldea is a full member of “Romanian Academy of Technical Sciences” (1999), a full member of “European Academy of Sciences and Arts” of Salzburg, Austria (2004), and a correspondent member of Romanian Academy. Prof. Boldea is an Honorary citizen of his hometown, Lugoj, in Romania. He received four IEEE-IA paper prizes (two IAS Committees (EMC and IDC) Conference prizes and two IA-Trans. Prize) in 1996, 1997, 1998, 2004, respectively.

Prof. Boldea has published extensively in linear and rotary motion electric machines design and control and MAGLEVS, including more than 200 papers and 18 books in USA and UK. Meanwhile, he has taught intensive courses repeatedly in the last 20 years in Europe, Asia, USA and Brazil and presented keynote addresses at numerous IEEE sponsored international conferences.