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ICEM'2022 TUTORIAL

TUTORIAL NAME: Multifunctional Self-Bearing Linear-Rotary Actuators

TUTORIAL PRESENTERS (Full Names, affiliations, and e-mails):

Spasoje Mirić, ETH Zurich, miric@lem.ee.ethz.ch
Rosario Giuffrida, ETH Zurich, giuffrida@lem.ee.ethz.ch
Dominik Bortis, ETH Zurich, bortis@lem.ee.ethz.ch

BIOS OF THE PRESENTERS (max 150 words each):

Spasoje Mirić received his B.Sc., M.Sc., and Ph.D. degrees in electrical engineering from the University of Belgrade, School of Electrical Engineering in 2012, 2013, and 2018 respectively, focusing on power electronics systems and drives. In 2021 he defended his second Ph.D. thesis at ETH Zurich at the Power Electronic Systems Laboratory (PES) in advanced mechatronic systems. During his Ph.D. project, he focused on linear-rotary actuator systems with magnetic bearings, which resulted in two new machine topologies patented. Since 2021, he has been with PES as a post-doc researcher, focusing on WBG power converter optimization with hard and soft-switching, new modulation techniques of flying capacitor converters, wireless power transfer systems, and eddy-current-based position sensor systems.

Rosario V. Giuffrida received the B.Sc. degree in Electronics Engineering from the University of Catania, Catania, Italy, in 2016, and the M.Sc. degree in Robotics, Systems, and Control in 2019 from the Swiss Federal Institute of Technology (ETH) Zurich, Switzerland, where he is currently working toward the Ph.D. degree in the advanced mechatronic systems area with the Power Electronic Systems Laboratory. His research interests include machine design, sensing, and motion control concepts for novel self-bearing linear-rotary actuators used in high-purity/medical applications.

Dominik Bortis received the M.Sc. and Ph.D. degree in electrical engineering from the Swiss Federal Institute of Technology (ETH) Zurich, Switzerland, in 2005 and 2008, respectively. In May 2005, he joined the Power Electronic Systems Laboratory (PES), ETH Zurich, as a Ph.D. student. From 2008 to 2011, he has been a Postdoctoral Fellow and from 2011 to 2016 a Research Associate with PES. Since January 2016 Dr. Bortis is heading the research group Advanced Mechatronic Systems at PES, which concentrates on ultra-high speed motors, bearingless drives, linear-rotary actuator and machine concepts with integrated power electronics. Targeted applications include e.g. highly dynamic positioning systems, medical systems, and future mobility concepts. Dr. Bortis has published 90+ scientific papers in international journals and conference proceedings. He has filed 30+ patents and has received 10 IEEE Conference Prize Paper Awards and 2 First Prize Transaction Paper Award.

ABSTRACT (max 200 words):

Linear-rotary actuators (LiRAs) are used in high-end applications such as pick-and-place robots in the semiconductor/pharmaceutical industry or implantable blood pumps. Both have exceptionally high hygiene requirements and high-precision requirements (sub-µm range). Such high demands are accomplished by employing self-bearing actuators. The self-bearing feature is enabled by integrating magnetic bearings (MBs) into a LiRA or a pump into a LiRA where hydraulic bearings (HBs) are realized. Both self-bearing enablers, MBs and HBs, feature high purity since there is no wear-and-tear, and MBs allow for high precision.

Join us in this tutorial that will discuss the applications of LiRAs and highlight challenges arising from the application requirements (e.g., stainless-steel encapsulation), and explain how these challenges are overcome with self-bearing LiRAs. We will then focus on the design of the LiRAs that integrate MBs/HBs and position sensors. Different realization options (e.g., checkerboard, double stator), actuator types (e.g., permanent magnet, reluctance), and sensor types will be covered. Finally, hardware prototypes of the newly proposed self-bearing LiRAs and measurement results will be shown. This tutorial highlights the research on advanced mechatronics at the Power Electronics Systems Laboratory of ETH Zurich.

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