TITLE:
MODEL PREDICTIVE CONTROL OF HIGH POWER CONVERTERS AND INDUSTRIAL DRIVES

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BIO

Tobias Geyer received the Dipl.-Ing. and Ph.D. degrees in electrical engineering in 2000 and 2005, respectively, and the Habilitation degree in power electronics in 2017, all from ETH Zurich, Switzerland.

After his Ph.D., he worked for GE Global Research, the University of Auckland and ABB Corporate Research. He was appointed as an extraordinary Professor at Stellenbosch University, South Africa, until 2023. In 2020, he joined ABB's medium-voltage drives business as R&D platform manager.

He is the author of 35 patent families and the book "Model predictive control of high power converters and industrial drives" (Wiley, 2016). He teaches a regular course on model predictive control at ETH Zurich. His research interests include medium-voltage and low-voltage drives, utility-scale power converters, optimized pulse patterns and model predictive control.

Dr. Geyer received the 2017 First Place Prize Paper Award in the Transactions on Power Electronics, the 2014 Third Place Prize Paper Award in the Transactions on Industry Applications, and two Prize Paper Awards at conferences. He is a former Associate Editor for the Transactions on Industry Applications and the Transactions on Power Electronics. He was an international program committee vice chair of the IFAC conference on Nonlinear Model Predictive Control in Madison, WI, USA, in 2018. Dr. Geyer is a Distinguished Lecturer of the Power Electronics Society in the years 2020 and 2021.

TUTORIAL ABSTRACT

Model Predictive Control of High Power Converters and Industrial Drives

This tutorial focuses on model predictive control (MPC) schemes for industrial power electronics in the MW range, particularly medium-voltage (MV) drives and MV grid-connected converters, including modular multilevel converters. These systems are predominantly based on multilevel voltage source converters that operate at switching frequencies well below one kHz. This tutorial proposes and reviews control methods that fully exploit the performance potential of high-power converters, by ensuring fast control at very low switching frequencies and low harmonic distortions. To achieve this, the control and modulation problem is addressed in one computational stage. Long prediction horizons are required for the MPC controllers to achieve excellent steady-state performance. The resulting optimization problem is computationally challenging, but can be solved in real time by branch and bound methods. Alternatively, the optimal switching sequence to be applied during steady-state operation—so-called optimized pulse pattern (OPP)—can be pre-computed offline and refined online to achieve fast closed-loop control. To this end, the research vision is to combine the benefits of deadbeat control methods (such as direct torque control) with the optimal steady-state performance of OPPs, by resolving the antagonism between the two. Three such MPC methods are presented in detail. The proposed control techniques can also be applied to low-voltage converters when operated at low pulse number, i.e. at small ratios between the switching frequency and the fundamental frequency. Examples for this include automotive and railway traction converters.

TUTORIAL GOAL

This tutorial follows a book by the instructor and his PELS distinguished lecture series. Two of the proposed MPC methods have been introduced in industrial medium-voltage drives. Experimental results from pilot installations will be shown and discussed in detail. The tutorial aims at providing a balanced mix of theory and application-related material. Special care is taken to ensure that the presented material is intuitively accessible to the power electronics practitioner. This is achieved by augmenting the mathematical formulations by illustrations and simple examples.