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Tutorial Title

Model Predictive Control: From Theory to Industrial Applications

Instructor Team

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Abstract

Conventional control methods fail to operate the power electronic systems in an optimal manner, causing the underutilization of the existing hardware. An attractive control alternative is model predictive control (MPC) due to its numerous advantages, such as explicit inclusion of design criteria and restrictions, design versatility, and inherent robustness. Thanks to these features, MPC can bring significant benefits by improving performance metrics (e.g., current distortion, power losses, settling time), and/or reducing the hardware requirements (or, equivalently, by fully utilizing the existing hardware).

Motivated by the above, the objective of this tutorial is to show MPC-based approaches that improve the performance of power electronic systems. To this aim, different algorithms will be discussed and analyzed, while design guidelines that maximize the performance benefits of MPC will be provided. Moreover, to clearly demonstrate the tangible improvements that MPC brings, it will be shown how MPC paved its way in industry by increasing the rated power of high-power converters, lowering their cost, and guaranteeing their safe operation in the presence of adverse operating conditions. Finally, a critical assessment of the existing MPC methods will be provided, and the tutorial will close with an outlook for MPC in power electronics and possible future research directions.

Overall, the tutorial aims at providing a balanced mix of theory and application-related material with a particular focus on the application of MPC in industry. 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. By the end of the tutorial, the attendees will be able to:

- have a good understating of MPC for power electronics,
- understand what design options exist that maximize the system performance,
- appreciate the benefits MPC brings to industry, and
- design MPC-based controllers that outperform conventional control techniques and push the system performance to its physical limits.

Instructor Biography

Tobias Geyer is a Corporate Executive Engineer at ABB's System Drives division in Switzerland. He is also the R&D platform manager of the ACS6000 and ACS6080, ABB's main medium-voltage drives. Working at the intersection of industry and academia he was appointed as an Extraordinary Professor at Stellenbosch University, South Africa. His main research interests are high-power drives, model predictive control and optimal pulse patterns. His vision is to develop control methods that maximize the power, efficiency and availability of power converters and drives. Tobias received the Dipl.-Ing. degree in electrical engineering, the Ph.D. in control engineering and the Habilitation degree in power electronics from ETH Zurich in the years 2000, 2005 and 2017, respectively. He has filed about 80 patents. Tobias received the PELS Modeling and Control Technical Achievement Award, the Semikron Innovation Award, the Nagamori Award, two Prize Paper Awards of IEEE Transactions and two Prize Paper Awards at IEEE conferences. He is a former Associate Editor of the IEEE Transactions on Industry Applications and the IEEE Transactions on Power Electronics. Tobias is a Fellow of the IEEE.

Qualifications most relevant to the proposal: Tobias is the author of the book ``Model predictive control of high-power converters and industrial drives''. He teaches a regular course on model predictive control at ETH Zurich. He also regularly gives seminars and tutorials at PhD schools, conferences, and other events. Finally, he is a Distinguished Lecturer of IEEE PELS.

Petros Karamanakos is an Associate Professor at the Faculty of Information Technology and Communication Sciences, Tampere University, Tampere, Finland. He received the Diploma and the Ph.D. degrees in electrical and computer engineering from the National Technical University of Athens (NTUA), Athens, Greece, in 2007, and 2013, respectively. Prior to joining Tampere University, he was with the ABB Corporate Research Center, Baden-Dättwil, Switzerland, and the Chair of Electrical Drive Systems and Power Electronics, Technische Universität München, Munich, Germany. His main research interests lie at the intersection of optimal control and modulation, mathematical programming and power electronics, including model predictive control for utility-scale power converters and ac variable speed drives. Petros received one Prize Paper Award of IEEE Transactions and two Prize Paper Awards at IEEE conferences. He serves as an Associate Editor of the IEEE Transactions on Industry Applications, and he is an IEEE Senior Member.

Qualifications most relevant to the proposal: Petros teaches a regular course on model predictive control of power electronic systems at Tampere University. He has also offered lectures and tutorials at PhD schools, conferences, and other events. Finally, he is a Regional (R8–Europe, Africa) Distinguished Lecturer of IEEE PELS.