

Tutorial 3, IECON 2018 (Monday, 22nd October at 9:30)

Model Predictive Control of Power Electronic Converters: Fundamentals, New Applications, and Performance Validation

1. Presenter(s):

Prof. Jose Rodriguez, Universidad Andres Bello, Chile, jose.rodriguez@unab.cl

Assoc. Prof. Tomislav Dragičević, Aalborg University, Denmark, tdr@et.aau.dk

2. Brief description

Model Predictive Control (MPC) is a conceptually simple yet powerful methodology to control power converters and electric drives. It has many advantages over traditional linear controllers including (i) faster response, (ii) high robustness to parameter variation (iii) explicit multivariable control accounting for the process and actuator constraints. Particularly, the finite-set MPC (FS-MPC) takes advantage of the discrete model of the converter to predict its future behaviour for every possible switching configuration. The predicted numerical values of converter's state variables at the next sampling step are then used in the cost function that defines the desired performance of the system. This approach yields a simple and intuitive implementation, where constraints of the state variables can be explicitly dealt with, while several performance objectives can be balanced by properly selecting the weighting factors associated with each objective. Due to these benefits and enabled by improvements in computational power of modern microprocessors, FS-MPC has been applied to numerous power electronic applications in the recent years. This tutorial will provide the fundamentals required to understand, design and implement state-of-the-art MPC methods in grid-connected power converters, electrical drives and microgrids. Furthermore, it will tackle some of the long-standing research problems associated with the FS-MPC, i.e. the analytical performance validation and the optimal tuning of the weighting factors in the cost function.

3. Outline

09:30 – 10:30 Model predictive control (MPC) in power electronics – Jose Rodriguez

10:30 – 11:30 MPC cost function design and performance validation – Tomislav Dragičević

11:30 – 11:45 Q&A

4. Publications relevant to the tutorial

J. Rodriguez et al., "Predictive Current Control of a Voltage Source Inverter," in IEEE Transactions on Industrial Electronics, vol. 54, no. 1, pp. 495-503, Feb. 2007.

S. Vazquez, **J. Rodriguez**, M. Rivera, L. G. Franquelo and M. Norambuena, "Model Predictive Control for Power Converters and Drives: Advances and Trends," in IEEE Trans. on Ind. Electron., vol. 64, pp. 935-947, Feb. 2017.

J. Rodriguez et al., "State of the Art of Finite Control Set Model Predictive Control in Power Electronics," in IEEE Transactions on Ind. Inf., vol. 9, no. 2, pp. 1003-1016, May 2013.

T. Dragičević, "Dynamic Stabilization of DC Microgrids with Predictive Control of Point-of-Load Converters," in *IEEE Trans. on Power Electron.*, vol. 33, no. 12, pp. 10872-10884, Dec. 2018.

T. Dragičević, "Model Predictive Control of Power Converters for Robust and Fast Operation of AC Microgrids," *IEEE Trans. on Power Electron.*, vol. 33, pp. 6304-6317, July 2018.

M. Novak, U. M. Nyman, **T. Dragičević** and F. Blaabjerg, "Analytical Design and Performance Validation of Finite Set MPC Regulated Power Converters," in *IEEE Trans. on Ind. Electron.*.

5. Presenter's biographies (IEEE style):



Jose Rodriguez (M'81–SM'94–F'09) received the Electrical Engineer degree from the Universidad Federico Santa Maria, Valparaiso, Chile, in 1977, and the Dr. Ing. degree in electrical engineering from the University of Erlangen, Erlangen, Germany, in 1985. Since 2015, he has been a Professor and a Rector with the Universidad Andres Bello, Santiago, Chile. He has co-authored more than 400 papers published in journals and conference proceedings, more than 100 of them in IEEE journals. His research interests include new converter topologies, multilevel inverters, control of power converters, and adjustable-speed drives. Prof. Rodriguez has received several Best Paper Awards from IEEE journals. He has been an Associate Editor of three IEEE journals. In 2015, he received the IEEE Industrial Electronics Society Dr. Ing. Eugene Mittelmann Achievement Award. He is a member of the Chilean Academy of Engineering.



Tomislav Dragičević (S'09–M'13–SM'17) received the M.E.E. and the industrial Ph.D. degree from the Faculty of Electrical Engineering, Zagreb, Croatia, in 2009 and 2013, respectively. From 2013 until 2016 he has been a Postdoctoral research associate at Aalborg University, Denmark. From March 2016 he is an Associate Professor at Aalborg University, Denmark. His principal field of interest is overall system design of microgrids, and application of advanced modelling and control concepts to power electronic systems. He has authored and co-authored more than 140 technical papers (more than 55 of them are published in international journals, mostly IEEE Transactions) in his domain of interest and 8 book chapters and a book in the field. He serves as an Associate Editor in the IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS and in the Journal of Power Electronics. Dr. Dragičević is a recipient of a Končar prize for the best industrial PhD thesis in Croatia, and a Robert Mayer Energy Conservation award.