Organisational Information

Sign up at: www.ecpe.org/events

Registration Deadline:

29 June 2023

Participation Fee:

- **€ 670,–** *   for industry
- **€ 520,–** *   for universities/institutes
- **€ 180,–** *   for students/PhD student
  (limited spaces; copy of students ID required)

* plus VAT

➢ The participation includes dinner, lunches, coffee/soft drinks and digital proceedings. The reduced (PhD) students fee includes all except for dinner (can be booked for an extra fee of € 50,-*)

➢ Digital proceedings will be provided by download link latest one day before start of the event. A printed handout is available on request (€ 50,-*).

➢ Upon receipt of registration confirmation via email you are signed-up for the event. The invoice will be sent via email.

➢ 25 % discount for participants from ECPE member companies.

➢ 10% discount on university/institute fee for participants from ECPE competence centres.

➢ Further information (hotel list and maps) will be provided after registration and can be found on the ECPE web page.

➢ Cancellation policy: Full amount will be refunded in case of cancellation upon to 2 weeks prior to the event. After this date 50 % of the fee is non-refundable (replacement is possible).

06/07/23

Organisational Information

Organiser	ECPE e.V. 90443 Nuremberg, Germany www.ecpe.org
Technical Chair	Dr. Tobias Geyer, ABB System Drives (CH)
	Prof. Dr. Ralph Kennel, Technical University of Munich (DE)
Technical Contact	Dr. Chris Gould, ECPE e.V. +49 911 81 02 88 – 21 chris.gould@ecpe.org
Organisation	Marietta Di Dio, ECPE e.V. +49 911 81 02 88 – 13 marietta.didio@ecpe.org
Venue	Hotel Gran Bilbao Avenida Indalecio Prieto, 1 48004 Bilbao | Spain

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European Center for Power Electronics e.V.

ECPE Tutorial

Model Predictive Control for Power Electronics, Drives and Power Grid Applications

06 – 07 July 2023
Bilbao
Spain

ECPE Tutorial

Model Predictive Control for Power Electronics, Drives and Power Grid Applications

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Model Predictive Control (MPC) is a conceptually simple yet powerful methodology to control power converters, electric drives and large systems, such as electrical power grids. MPC provides many advantages over traditional controllers including the capability to intuitively handle a large variety of control problems by considering different modes of operation and directly incorporating system constraints and additional requirements. The underlying concepts are intuitive, the resulting controllers are inherently stable and, once calculated, easy to implement. The advances in processing power of digital signal processors have recently promoted MPC into the first commercial applications, which opened a door toward improved performance and efficiency of power converters, drives and power grids.

The goal of this tutorial is to provide working knowledge on the development and implementation of MPC in different application fields. The introduction teaches the basic MPC principles, including mathematical techniques and optimization methods necessary to formulate and solve the control problem. The subsequent application-specific presentations address practical challenges in MPC of drives, grid connected converters, photovoltaic inverters and electrical power grids. Case studies demonstrate practical MPC controller designs, and evaluate and discuss their results. The embedded implementation section provides practical implementation guidelines by addressing hardware, software, programming methods and suitable design tools. Finally, in the last session, advanced MPC concepts are explained and demonstrated on examples

Course Instructors

Dr. Tobias Geyer, ABB System Drives (CH)
Prof. Dr. Ralph Kennel, TU Munich (DE)
Prof. Dr. Steven Liu, TU Kaiserslautern (DE)

All presentations and discussions will be in English.

Programme

Thursday, 6 July 2023

08:30 Registration & Welcome Coffee

09:00 Welcome and Tutorial Opening
Chris Gould, ECPE

Introduction and Basic Concepts

09:15 Introduction and Basic Concepts, R. Kennel
- Basic Principle of Predictive Control
- Trajectory based and Hysteresis based Predictive Control
- Benefits of Predictive Control

10:00 Control Theory, T. Geyer
- Introduction to control theory
- State-Space Modeling
- MPC Concept

10:45 Coffee Break

11:15 Numerical Optimization, T. Geyer
- Introduction to Mathematical Optimization
- Convex and Non-convex Problems

11:45 Linear MPC, S. Liu
- A Simple Numerical Example in Matlab

12:30 Lunch

Direct MPC

13:30 Introduction to FC S-MPC and Applications, R. Kennel
- Comparison of Conventional Control and MPC
- MPC of AC/DC Converters
- Current Control of Three Phase Inverters
- Model Predictive Power Control in Active Front End and Further Examples

14:30 Generalization to Long Horizon FC S-MPC, T. Geyer
- Derivation of the Integer Optimization Problem and Sphere Decoding
- Drive System with LC Filter
- Tuning Guidelines

15:30 Coffee Break

15:45 Direct MPC of Photovoltaic Inverters, R. Kennel
- Case Study: Design of MPC for Quasi Z-Source Inverters with LC Filters
- Validation and Evaluation of the Performance

MPC of Power Grids

16:30 MPC for Electrical Power Grid, S. Liu
- Control Problem Formulation
- Mathematical Model of Power Grid
- Optimisation Solution
- Validation and Evaluation of the Performance

18:00 Open Questions from the 1st day

18:15 End of 1st Day

20:30 Dinner at Restaurant „Aitxiar"

Programme

Friday, 7 July 2023

08:30 Start of 2nd Day

PMW based MPC Concepts

09:00 MPC based on Optimized Pulse Patterns, T. Geyer
- Optimized Pulse Patterns
- Fast Control of Optimized Pulse Patterns

10:00 Indirect MPC (Part 1), T. Geyer
- Indirect MPC of three-phase Grid-connected Converters (a numerical example)

10:30 Coffee Break

10:45 Indirect MPC (Part 2), T. Geyer
- Indirect MPC for Modular Multilevel Converters
- MPC of LCI Drives

Implementation

11:45 Algorithms and Embedded Implementation of MPC, S. Liu
- Embedded MPC Implementation: Hardware and Software
- Embedded MPC with SoCs
- A Workflow Example – MPC for a Grid-connected Converter with DSP and FPGA

12:45 Lunch

Advanced Topics

13:45 Advanced MPC Topics, T. Geyer
- Stability
- Explicit Solution of MPC
- Hybrid Systems

14:15 Further MPC Concepts, S. Liu
- Hierarchical MPC
- Distributed MPC
- Data-driven MPC

Summary and Discussion

15:15 Summary, T. Geyer

15:45 Q & A and Discussion

16:15 End of Tutorial