

Masterthesis

Automated tuning of the MPC cost function of a MMC using Bayesian optimization

Description

The modular multilevel converter (MMC) is a key technology for high-voltage dc (HVDC) transmission and medium-voltage drives. Its many coupled states, nonlinearities, and strict operating limits require advanced control, such as model predictive control (MPC), to ensure safe operation.

The weights of the MPC cost function are usually tuned by hand: this is slow and yields a single compromise for the entire operating range. Since every candidate must be judged by a full closed-loop simulation, an exhaustive search is prohibitively expensive. Bayesian optimization reaches a good design within a few dozen simulations by learning a probabilistic surrogate of the performance. Its safe variant avoids weights that would violate the real current limits, so the tuning can run directly on the test bench, and treating tracking accuracy and control effort as separate objectives yields a Pareto front of optimal compromises. This thesis applies Bayesian optimization to tune the MPC of the MMC and selects the weights according to the operating point.

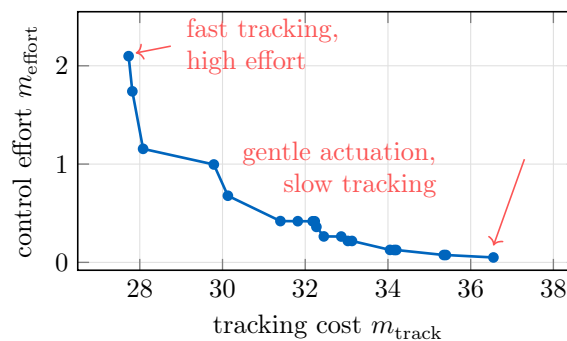


Figure 1: Pareto front of tracking accuracy against control effort: every point is an optimal compromise, and the operating point decides which one to use.

Tasks

- State of the art of automated controller tuning and Bayesian optimization.
- Definition of closed-loop performance metrics for the MMC (tracking, control effort, constraint violation).
- Implementation of a safe Bayesian optimization loop over closed-loop simulations of the MMC.
- Computation of the Pareto front and design of an operating-point-dependent weight schedule.
- Implementation of the proposed algorithms in Matlab & Simulink.
- Experimental validation on the real setup (see figure 2).

What we offer

- Work on a real MMC testbench: your algorithm runs on actual hardware, not only in simulation.
- Results can form the basis for a scientific publication.
- Dedicated student workplaces right next to the lab.
- Bayesian optimization is widely used in machine learning and engineering design; you learn a method that applies to any expensive tuning problem.
- Start date is flexible.

Prerequisites

- Background in control engineering and basic knowledge of probability and statistics.
- Experience with Matlab & Simulink.
- Interest in machine learning methods and in automating what is usually done by hand.

Contact and further information

- The thesis can be written in English or German.
- Supervision by Leonardo Testa, M.Sc., with weekly meetings.

For questions and application contact Leonardo Testa, M.Sc. (leonardo.testa@hm.edu).

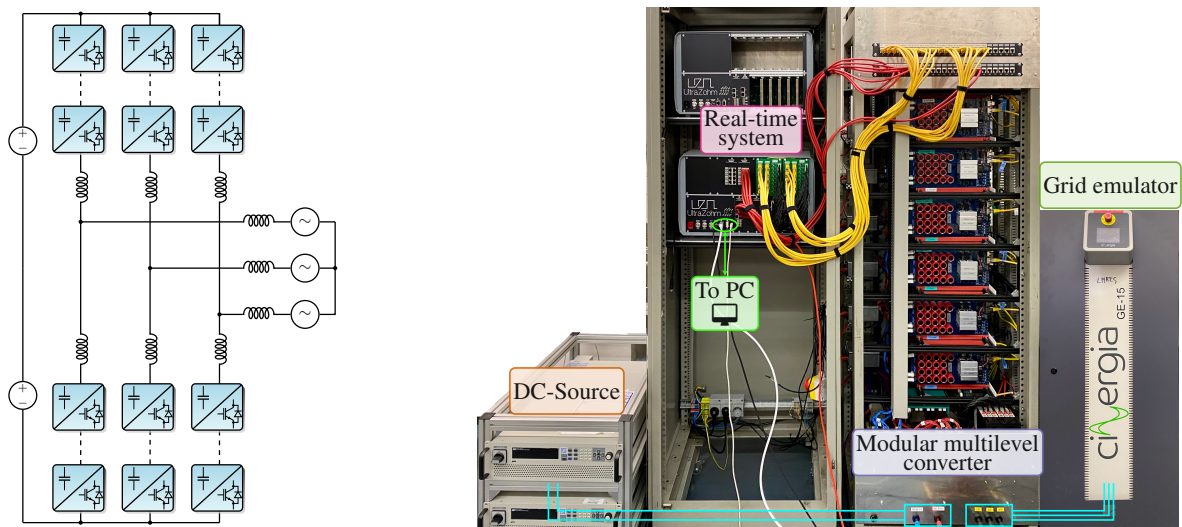


Figure 2: MMC schematic and testbench