

Masterthesis

MPC cost function design for modular multilevel converter (MMC) via controller matching

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.

In power electronics, the weighting matrices of the MPC cost function are almost always tuned by hand until the simulated response appears acceptable. Consequently, the closed-loop system has no stated bandwidth, damping, or robustness margin. Classical control design starts with an explicit specification. This thesis bridges the gap between MPC and classical approaches. First, it designs a target controller for the MMC using H_2 or H_∞ synthesis. The desired bandwidth, disturbance rejection, and noise sensitivity are encoded as frequency-domain weights. Next, the MPC cost matrices are computed backward from the target controller to ensure that the unconstrained controller reproduces the target precisely. Finally, the resulting closed-loop system is assessed in the frequency and time domains and compared to a conventionally tuned MPC to determine if the specified margins are met.

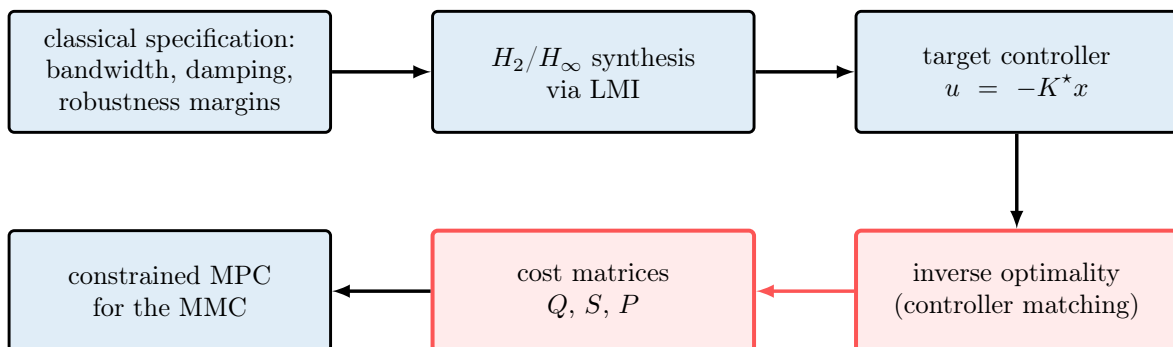


Figure 1: Controller matching: a classically designed target controller is translated into MPC weights instead of tuning them by hand.

Tasks

- State of the art of weight selection for predictive controllers, from Bryson's rule and the LQR–Riccati connection to controller matching.
- H_2 and H_∞ synthesis via linear matrix inequalities, applied to the MMC .
- Computation of the MPC cost matrices by inverse optimality (controller matching).
- Assessment of the resulting closed loop in frequency and time domain.
- Implementation and validation 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.
- Learn to derive a predictive controller from a specification, combining classical robust control with modern optimization.
- Start date is flexible.

Prerequisites

- Solid background in control engineering, in particular frequency-domain design and state-space methods.
- Experience with Matlab & Simulink; interest in convex optimization.
- Enjoyment of theory that ends up running on real hardware.

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).

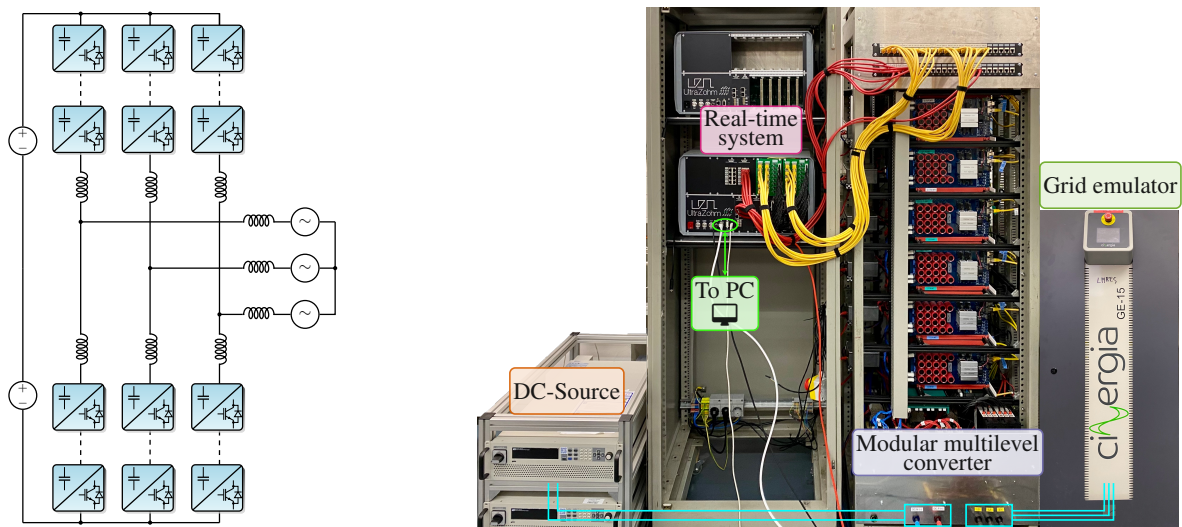


Figure 2: MMC schematic and testbench