

Bachelor- / Masterthesis

Offset-free model predictive control (MPC) for modular multilevel converter (MMC)

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.

No real converter matches its MPC model exactly: parameters drift and the prediction model is deliberately simplified. The result is a steady-state offset, where the controlled quantity settles close to, but never on, its reference. Shorter sampling times, longer horizons, or different weights cannot remove it, because the controller has no model of the mismatch. The established remedy is to augment the prediction model with an estimated disturbance state that cancels the model error. This thesis designs, implements, and validates such an offset-free MPC for the MMC.

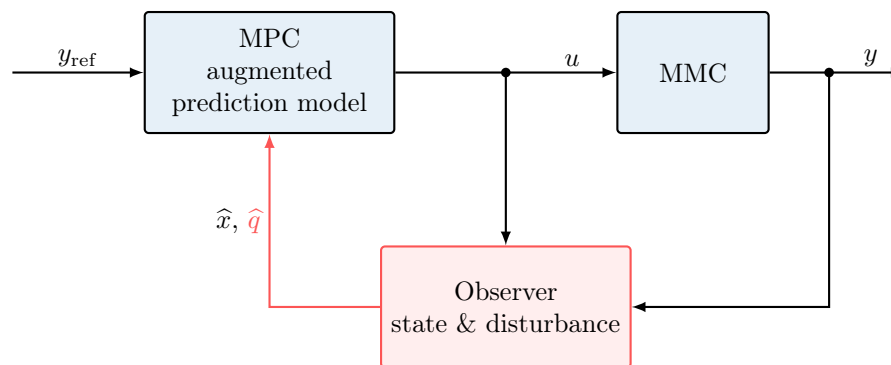


Figure 1: Offset-free MPC: the prediction model is augmented by a disturbance state q , which an observer estimates online from the measured output.

Tasks

- State of the art of offset-free MPC and disturbance modeling for predictive controllers.
- Analysis of the origin of the steady-state offset in the existing MMC control loops.
- Design of the augmented prediction model, and verification of the conditions for offset-free tracking.
- Design of the estimator (e.g. Kalman filter, extended state observer, etc.).
- Comparison against the integral-state augmentation including their behavior under active constraints.
- 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.
- A topic at the interface of control theory and power electronics: observer design and MPC are in demand in the converter, drive, and grid industry.
- Start date is flexible.

Prerequisites

- Solid background in control engineering, in particular state-space methods and observer design.
- Experience with Matlab & Simulink.
- Interest in power electronics and in bringing an algorithm from theory to a real converter.

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).

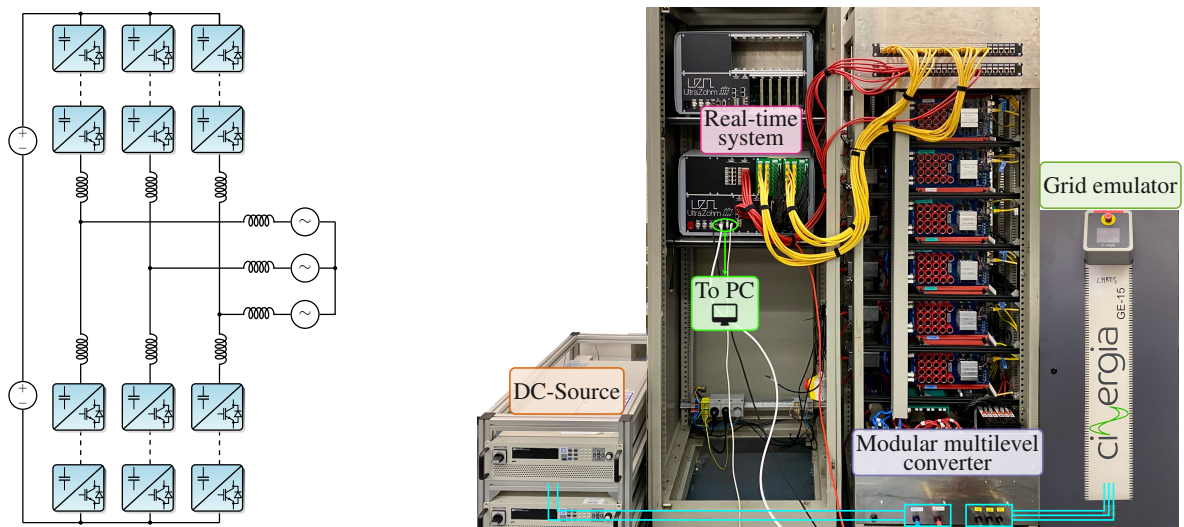


Figure 2: MMC schematic and testbench