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Master thesis   Date: dd.mm.yyyy

Development of a Model Predictive Control Algorithm for the predictive control of distributed energy conversion units and On Load Tap Changers

In the course of the energy transition, large power plants such as nuclear and coal-fired power plants are being shut down in Germany and replaced by decentralized generation plants such as photovoltaic and wind power plants. This leads to a shift of feed-in from the transmission to the distribution grids and thus to bidirectional power flows as well as a new understanding of the provision of ancillary services. Moreover, new loads such as electric vehicles and heat pumps are being deployed to the distribution grids. These decentralized generation units and decentralized loads cause an increase of voltage congestions and thermal congestions, especially at the low voltage level. It has been shown that physical grid expansion is not the most efficient solution to solve the newly arising grid congestions; it also does not enable the assets in the distribution grids to provide ancillary services to the power system.

An increasingly popular control method to deal with congestions in power grids is the Economic Model Predictive Control (MPC) which allows the user to control assets considering predictions of the system behavior over a time horizon. At the ie³ institute, the MPC method was used to control assets to prevent voltage and thermal violations from occurring while minimizing the control impact on the grid. Moreover, MPC has been used to serve redispatch demands by higher grid levels in a non-discriminating fashion. However, in all of these use cases, the flexibility of on load tap changers has not been included in the optimization, often resulting in suboptimal usage of the given flexibilities in the grid. In this thesis, the existing MPC algorithms are to be extended by including the discrete decision of stepping a given on load tap changer. The new algorithm is to be developed, scenarios to be defined, and the functionality of the algorithm to be verified in simulations. To reduce the computational effort, only linear models of the power flow equations are to be considered.

The following structuring of the work is proposed:

1) Get familiar with the concept of MPC and its already existing implementations at ie³.
2) Investigate possible power flow linearization schemes w.r.t. their applicability in MPC.
3) Conduct research on integration of discrete decision variables into MPC. To this end, approaches like MIQP (Mixed Integer Quadratic Programming) and QP (Quadratic Programming) with decision trees and pruning can be considered.
4) Develop the selected MPC formulation based on the selected linear model for congestion management and redispatch provision in distribution grids.
5) Implement the algorithm in Python or Julia.
6) Define scenarios to test the developed algorithm.
7) Test the implementation, analyze and optimize the results.

Following this work, the results are to be reported in a presentation. This thesis is issued as a master thesis for students of industrial engineering, electrical engineering and Automation and Robotics.

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