PhD Dissertation Synthesis

Title: Offset-Free Model Predictive Control for Active Magnetic Bearings

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The thesis deals with the study of Offset-Free Model Predictive Control (OF-MPC) for Active Magnetic Bearing (AMB) systems. OF-MPC is a systematic approach to optimally handle the trade-off between control effort and controlled outputs taking into account plant dynamics and constraints. The term "Offset-Free" stands for the possibility to compensate the plant-model mismatch and guarantee zero-offset at steady state based on the external disturbance estimate. A procedure for the overall design is presented and supported by numerical simulations and experimental works conducted in two test rigs: a single-degree-of-freedom AMB system and a more complex cone-shaped AMB system. The results demonstrate that with OF-MPC the coil current limitations are optimally handled and the plant-model mismatch is quantified real-time in terms of disturbance forces. The approach is also effective in guaranteeing stability and rejecting external disturbance forces. The application of OF-MPC is a novel and promising constrained optimal control technique for cone-shaped AMB systems since the main control difficulties: (i) coupling of radial and axial control actions, and (ii) the low force generation capability in axial direction, can be addressed in a clear and systematic way. The results also demonstrate that OF-MPC outperforms Proportional-Integral-Derivative controllers in the compensation of axial external forces. The main contribution of this thesis is the numerical and experimental demonstration of the potentiality of OF-MPC for AMB systems, together with a methodology for its implementation. Furthermore, the control algorithm is described in detail showing how to: reduce the computational burden of the control problem, generate OF-MPC solvers from C code generation tools and design properly the plant state estimator.