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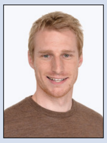
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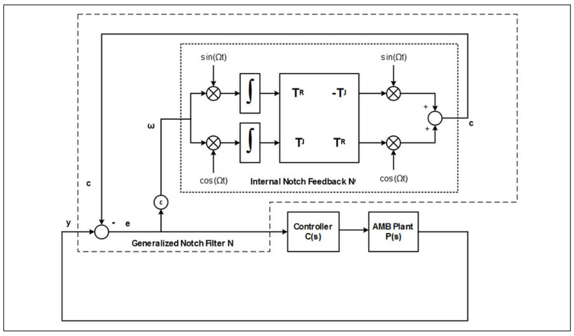
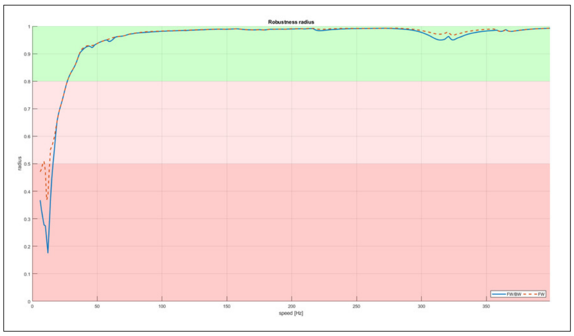
Subject Area	Control Theory
Project Partner	Mecos AG, Zürich, ZH

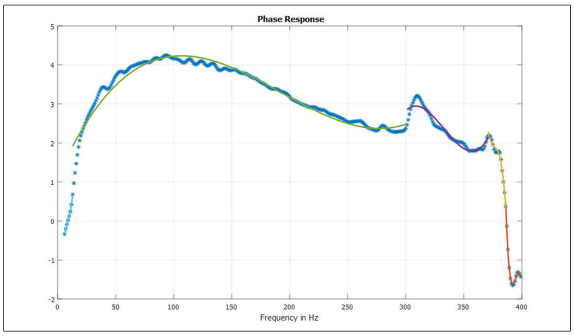
Optimized MIMO-Control for Magnetic Bearing Systems



Generalized Notch Filter inserted into Control Loop
Source: IEEE Trans. on CST, ID: 1063-6536(96)06624-9



Robustness Radius of decoupled Adaption Matrix
Own Depiction



Third order Polynomial Approximation of Phase Response
Own Depiction

Introduction: Fast spinning machinery such as turbo pumps, compressors, turbo blowers or centrifuges are used in many applications across different industries. The main advantages of the high rotational speeds (which can amount to tens of thousands of revolutions per minute) include an overall greater efficiency and a similar power output at a reduced system size. The major drawback though, is the increased performance requirement of the shaft bearings. Above certain rates of rotation, conventional methods like sleeve or roller bearings are no longer applicable due to friction and abrasion.
This is where so-called active magnetic bearings (AMB) come into play. In AMBs, the turning arbor is levitated and positioned by means of electromagnets. Since there is no direct contact between moving parts of the machinery, magnetic bearings represent a sophisticated, wear-free alternative to conventional systems.
By letting the shaft hover freely, it can be rotated around its inertial axis instead of its geometric one. In this way, almost no mass unbalances occur, leading to a minimization of possible vibrations. One way to achieve this is by inserting a notch filter into the control loop that removes unbalance disturbances from the measured position signals.

Objective: For the above mentioned filter to work, the different frequency responses of the magnetic bearing have to be measured and stored before deployment. This data is used to parametrize the rotational speed dependent notch filter. The amount of metered data can be quite extensive. If the quantity of the data is reduced, demands for the hardware capabilities decrease and potential cost savings arise.
In the current solution, the frequency responses are approximated by third order polynomials, and only their coefficients are kept. The frequency responses are then recalculated from the coefficients in real-time during operation.
The objective of this thesis is to investigate further data reduction, one strategy being a decoupling of the system channels. For evaluating the usefulness of the developed algorithms, the primary cost function is the resulting robustness of the whole system and not the actual Goodness-of-Fit.

Result: Several different approaches to approximate the frequency responses are pursued. This includes iterative as well as non-iterative solutions. Various strategies are employed and combined to find the most effective one in terms of results and calculation time.
It is shown that a substantial reduction in the amount of data is indeed possible, while maintaining robustness, stability and convergence time. The best outcomes are achieved by solving an optimization problem based on the eigendecomposition of the system.