Multivariable performance analysis of position-controlled payloads with flexible eigenmodes

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Abstract

Due to a continuously increasing complexity, more stringent and demanding requirements of highly sophisticated and dynamically coupled mechatronic systems, Multiple-Input Multiple-Output (MIMO) modelling, control and analysis techniques need to be considered to ensure a more accurate and advanced mechatronic system design. In this context, the paper investigates the control performance analysis of multivariable systems by using sensitivity function peak. Three different system representations are chosen, which represent the system in different aspects and thus provide an alternative to the analysis of the complete multivariable system.

An idealized dynamically coupled MIMO model, derived from basic principles, representing the dynamic behaviour of an actuated and position-controlled payload with flexible eigenmodes is modelled. The analytical description allows the system adaptation for the investigation of different specifications and system characteristics, e.g. the coupling ratio and therefore the multivariable character of the system. Subsequently, it is derived and explained why the sensitivity function peak is a suitable parameter to describe the control performance of position-controlled MIMO systems. The three system representations are theoretically derived and applied on the dynamically coupled MIMO model. These representations focus on investigating the multivariable system character with simplified, partly SISO based approaches and thus reduce the complexity of the analysis. Among others, the method of individual channel analysis and design (ICAD) presented by O'Reilly and Leithead is applied and extended. The performance of each resulting system representation is analysed and compared.

Based on these analyses, it is discussed under which conditions multivariable systems should be investigated with multivariable performance analysis methods and when a system simplification to a SISO based approach is valid and can be chosen. Finally, these results and observations are used to derive guidelines and recommendations for the performance analysis of multivariable position-controlled payloads with flexible eigenmodes.