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Disturbance feedforward control for air mount systems with acoustic resonances

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1 Introduction

Disturbance feedforward control (DFC) can be used to improve disturbance suppression performance of air mount systems with air tanks. Those tanks often give rise to acoustic resonances that subsequently limit performance. This paper, which is in line with our work in [1], presents a self-tuning DFC strategy that improves performance and can deal with acoustic resonances.

A description of the uncontrolled air mount system consists of the transfer functions P_1 (from base frame acceleration r to payload accleration y), and P_2 (from control force u to y). Bode diagrams for P_1 and P_2 are given in Figure 1, which assumes a fourth-order model with one acoustic resonance.

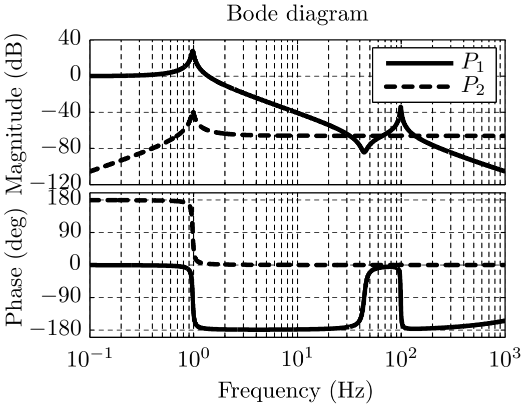

Figure 1: Bode diagrams for P_1 (solid) and P_2 (dashed).

2 Disturbance feedforward control

Figure 2 shows the self-tuning controller structure. Using the z-transformation, the control signal reads

$$U(z) = \sum_{i=1}^{4} w_i(z)\mathcal{B}_i(z)R(z), \tag{1}$$

with $z \in \mathbb{C}$, basis functions $\mathcal{B}_i$ which are orthonormal [2] to optimize convergence speed, and self-tuning weights w_i. The goal is to find all w_i such that the filtered-error e is minimized. This is done with a self-tuning algorithm based on Filtered-error Least Mean Squares (FeLMS). The update block in Figure 2 performs the updates of w_i. Filter F removes sensor noise, and N is used for residual output shaping in the frequency domain. Two feedforward controllers C_{FF} are considered, i.e. a reduced-order (RO) controller and a full-order (FO) controller. The RO controller has two basis functions, while the FO controller has four basis functions. The latter can compensate for the acoustic resonance.

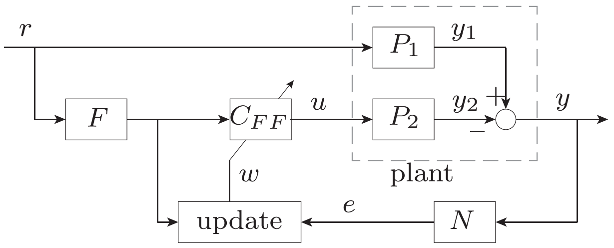

Figure 2: Implementation of the self-tuning controller.

3 Results

Figure 3 shows Bode plots of transmissibility functions,

$$T(s) = P_1(s) + P_2(s)C_{FF}(s)F(s), \tag{2}$$

i.e. the transfer functions from r to y. It is observed that the RO controller only increases disturbance suppression up to the acoustic resonance frequency. The FO controller also increases performance at frequencies beyond the acoustic resonance. The controlled systems suffer from performance deterioration at very low and high frequencies due to causality aspects [3].

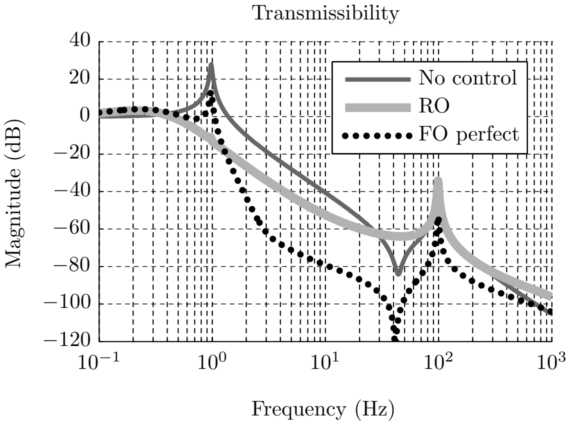

Figure 3: Transmissibility functions

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