Topic ID: 333-IT-EN-01

Design and Optimization of Multiple-Frequency Noncollocated Vibration Absorber Using Delayed Feedback

Supervisor: doc. Ing. Libor Pekař, Ph.D.

Consultant: Assoc. Prof. Qingbin Gao, Ph.D.

Department: Department of Automation and Control Engineering

Programme: Information Technologies

Abstract:

The proposed dissertation thesis topic constitutes a comprehensive exploration into the design and optimization of a multiple-frequency noncollocated vibration absorber, integrating the delayed feedback control. Traditional absorbers have predominantly concentrated on single-frequency, collocated vibration suppression, often disregarding the intricate dynamics inherent in real-world structures hosting diverse modes of noncollocated vibration. In response, this study pioneers a novel noncollocated absorber adept at simultaneously mitigating vibrations across various frequencies. Noncollocated solutions introduce unparalleled flexibility for effectively suppressing vibrations in remote locations, thereby broadening the practicality of vibration control within scenarios constrained by spatial limitations. Moreover, the research paradigm of this dissertation thesis transcends the conventional view of delay as a limitation, leveraging delayed feedback control to enhance the control performance and magnify adaptability to evolving structural conditions. This paradigm shift empowers the absorber for real-time dynamic optimization, attuning its performance to the dynamic nature of the structure. The doctoral student should endeavor to systematically explore and delineate optimal design parameters for these absorbers, accommodating an array of structural configurations and adapting to varying environmental conditions.

Literature:

[1] CAI, Jiazhi; GAO, Qingbin; LIU, Yifan and OLGAC, Nejat. Control design, analysis, and optimization of fractional-order delayed resonator for complete vibration absorption. Journal of Sound and Vibration. 2024, vol. 571, art. no. 118083. ISSN 0022-460X. DOI: 10.1016/j.jsv.2023.118083.

[2] OLGAC, Nejat and JENKINS, Ryan. Actively tuned noncollocated vibration absorption: An unexplored venue in vibration science and a benchmark problem. IEEE Transactions on Control Systems Technology. 2021, vol. 29, no. 1, pp. 294-304. ISSN 1063-6536. DOI: 10.1109/tcst.2020.2973603.

[3] SILM, Haik; KUŘE, Matěj; BUŠEK, Jaroslav; MICHIELS, Wim and VYHLÍDAL, Tomáš. Spectral design and experimental validation of noncollocated vibration suppression by a delayed resonator and time-delay controller. IEEE Transactions on Control Systems Technology. 2024, vol. 32, no. 1, pp. 73-85. ISSN 1063-6536. DOI: 10.1109/tcst.2023.3297773.

[4] VALÁŠEK, Michael; OLGAC, Nejat and NEUSSER, Zdeněk. Real-time tunable single-degree of freedom, multiple-frequency vibration absorber. Mechanical Systems and Signal Processing. 2019, vol. 133, art. no. 106244. ISSN 0888-3270. DOI: 10.1016/j.ymssp.2019.07.025.

[5] VYHLÍDAL, Tomáš; MICHIELS, Wim; NEUSSER, Zdeněk; BUŠEK, Jaroslav and ŠIKA, Zbyněk. Analysis and optimized design of an actively controlled two-dimensional delayed resonator. Mechanical Systems and Signal Processing. 2022, vol. 178, art. no. 109195. ISSN 0888-3270. DOI: 10.1016/j.ymssp.2022.109195.

[6] SALDANHA, Adrian; PEICHL, Adam; MICHIELS, Wim and VYHLÍDAL, Tomáš. Delayed dynamic-feedback controller design for multi-frequency vibration suppression. IFAC-PapersOnLine. 2024, vol. 58, no. 27, pp. 196-201. ISSN 2405-8963. DOI: 10.1016/j.ifacol.2024.10.323.

[7] AKBARISISI, Sanaz and MICHIELS, Wim. Spectrum-based stability analysis and stabilization of systems with time-periodic delay differential algebraic equations. European Journal of Control. 2025, vol. 86, art. no. 101400. ISSN 0947-3580. DOI: 10.1016/j.ejcon.2025.101400.

[8] PEICHL, Adam; KUŘE, Matěj; MICHIELS, Wim and VYHLÍDAL, Tomáš. Integrated design of system structure and delayed resonator towards efficient non-collocated vibration absorption. Journal of Sound and Vibration. 2025, vol. 612, art. no. 119101. ISSN 0022-460X. DOI: 10.1016/j.jsv.2025.119101.

[9] SALDANHA, Adrian; MICHIELS, Wim and VYHLÍDAL, Tomáš. Non-collocated vibration suppression using delay-based controllers with multiple fixed delays. IFAC-PapersOnLine. 2023, vol. 56, no. 2, pp. 180-185. ISSN 2405-8963. DOI: 10.1016/j.ifacol.2023.10.1566.

[10] GAO, Qingbin; CAI, Jiazhi; WU, Hao; ZHOU, Kai and PEKAŘ, Libor. Complete stability analysis and optimal design for dual-state-feedback delayed resonator. Journal of the Franklin Institute. 2026, vol. 363, no. 4, art. no. 108432. ISSN 0016-0032. DOI: 10.1016/j.jfranklin.2026.108432.