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Control of vibration suppression of plate with a grid of actuators and sensors

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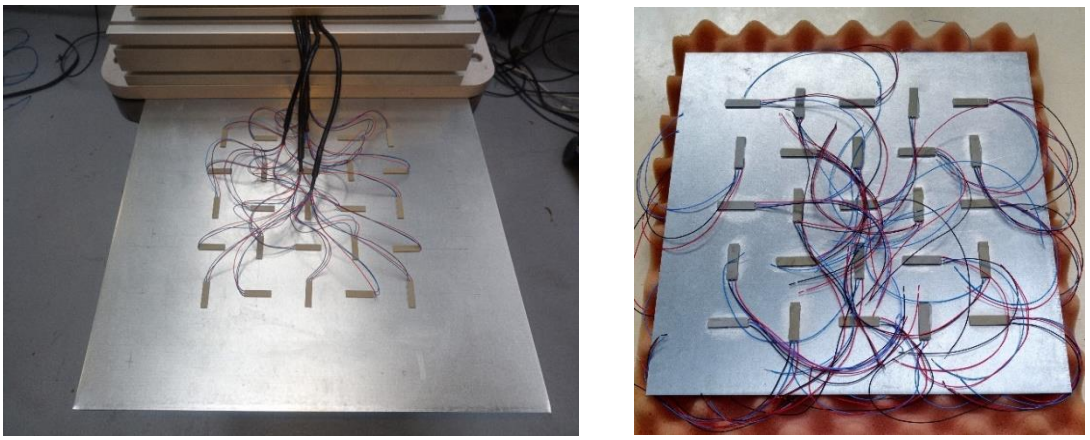
The paper deals with the optimization of active vibration suppression of plate demonstrator equipped by regular grid of 5x5 actuators and their collocated 5x5 sensors realized by planar piezo patches [1]. Robust H-infinity design with fixed order controller of predefined structure and LQR design using implementation with the states observer have been investigated. The influence of different boundary conditions (examples in Fig. 1) of the plate to efficiency of different control law concepts is the main topic of research. The ideal target is an easy tunable, scalable, active vibration suppression control law, defined by a limited number of independent parameters and optimized dominantly based on the local dynamical properties of the compact actuator-sensor-matrices and only finally tuned taking into account the particular global mechanical configurations (e.g. boundary conditions).



a) cantilever active plate b) "free" active plate

Fig. 1. Plate demonstrator with grid of piezo patches as actuators and sensors

H-infinity synthesis with predefined controller structure is frequency-domain optimization method for controller tuning. HIFOO solver [2] or *hinfstruct* function in Robust control toolbox in MATLAB have been the first method used for solving this task. Simulation model of the plate equipped with 25 actuators (control inputs U_i) and 25 collocated sensors (measured outputs Y_i) has been used for design and validation of selected control laws. They are designed using the H infinity structured optimization methodology to attenuate resonant modes of this flexible structure. The local controllers were considered in simple decentralized form

$$U_i = -k_i Y_i = -p_i \frac{s}{s+f_c} Y_i \,, \tag{1}$$

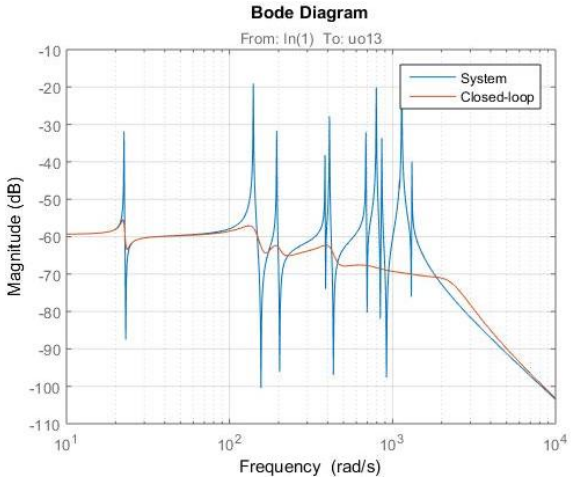
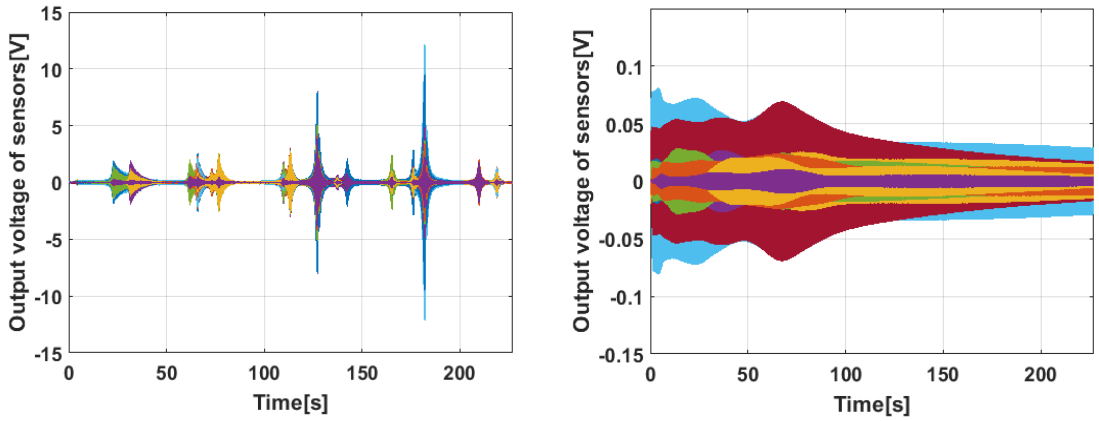


Fig. 2. Example of Bode diagram for H-inf decentralized feedback control

or in more complex form, where the control action applied to each patch depends also on measured outputs at the neighboring sensoring patches. Example of achievable results are presented in the form of Bode diagram (Fig. 2).

The second variant of the control law has been synthetized using well known LQR method with a state observer using sensory piezo-patches outputs. The achievable results have been comparable with the fixed order H-inf strategy. The different variants of excitation/disturbance have been considered and tested. The limits of control voltage of actuators have been taken into account using penalization matrix. The comparison of response of original and actively damped cantilever plate is in Fig. 3 for chirp excitation/disturbance by couple of perpendicular piezo patches no. 13 and 14. The control design using both mentioned techniques and the verification experiments are still in intense development.



a) response of original system b) response with feedback control

Fig. 3. Example of simulation time responses of all piezo-patch sensors to chirp excitation

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[2] Burke, J.V., Henrion, D., Lewis, A.S., Overton, M.L., "HIFOO - A MATLAB Package for fixed-order controller design and H-infinity optimization, In *IFAC Symposium on Robust Control Design*, Toulouse, 2006.