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LATERAL VIBRATION ATTENUATION OF A BEAM WITH CIRCULAR CROSS-SECTION BY SUPPORTS WITH INTEGRATED RESONANTLY SHUNTED PIEZOELECTRIC TRANSDUCERS

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Summary: Undesired vibration may occur in lightweight structures due to excitation and low damping. For the purpose of vibration attenuation, resonant shunting of piezoelectric transducers can be an appropriate measure. This technique transfers mechanical vibration energy from the mechanical structure into an electrical vibratory system, resulting in reduced vibration of the mechanical structure.

In the proposed paper, lateral vibration attenuation of a beam with circular cross-section by integration of resonantly shunted transducers in the beam's two supports is investigated numerically and experimentally. Elastic spring elements in both supports bear lateral forces and enable rotation at the beam's ends, thus, defining centers of rotation. In each support of the beam, three piezoelectric stack transducers are arranged in the support housing at an angle of 120° to each other, orthogonal to the beam's longitudinal axis and in one plane. They are connected with the center of rotation at the beam's end via a relatively stiff axial extension, forming a cantilever beam beyond both spring elements. With that, bending of the beam is transformed into the stack transducer's axial deformation. Together, the elastic spring elements and the piezoelectric transducers form the actual beam supports. For vibration attenuation, resonant shunts including a resistor, inductance and negative capacitance (RLC-shunt) are chosen.

The lateral vibration of the flexible beam is numerically simulated with a finite element model using one-dimensional beam elements with six degrees of freedom at each node. The nodes at both ends are connected to piezoelectric stack transducer elements with resonant shunts. Rotational spring elements represent the elastic spring elements. Numerical simulations in the frequency domain are performed to calculate the general electromechanical coupling coefficient and show the influence of geometry and stiffness properties of the elastic spring elements. Frequency response functions of the beam's lateral deflection due to excitation by lateral forces are calculated to show the vibration attenuation potential of the proposed approach. Furthermore, experimental investigations validate the electromechanical coupling and the vibration attenuation of the beam with resonantly shunted piezoelectric transducers.