Summary of Final report

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Summary

The area of vibration control is evolving rapidly primarily due to high demand of low weight structures in automobile sector. To ensure that vibration control happens efficiently when the product is in field, vibration testing of product is required in a laboratory in an environment that resembles that of field. In this study, a novel technique is presented for generating desired transient vibrations in a test plate structure.

For this, first three vibration modes of a cantilevered plate have been simultaneously made to track reference curves. Cantilevered plate structure is instrumented with one piezoelectric sensor patch and one piezoelectric actuator patch. Quadrilateral plate finite element having three degrees of freedom at each node (two rotations and one flexural displacement) is employed to divide the plate into finite elements. Thereafter, Hamilton's principle is used to derive equations of motion of the smart plate. In Hamilton's principle kinetic energy, potential energy and work expressions of a single finite element of smart plate are substituted. Variations with respect to displacement vector are taken to derive mass matrix, stiffness matrix and force vector of finite element model. Finite element model of structure is reduced to first three modes using orthonormal modal truncation and subsequently the reduced finite element model is converted into a state-space model. Optimal tracking control is then applied on the state-space model of the smart plate. Optimal control law optimizes a performance index which results in minimization of difference between actual trajectories and reference trajectories using minimal control effort. Feedback gain and feedforward gains of controller are calculated offline by solving a Riccati equation. Using this optimal controller, cantilevered plate is made to vibrate as per desired decay curves of first three modes.

Simulation results show that presented optimal control strategy is very effective in simultaneously tracking first three vibration modes of the smart plate. Theoretical findings are verified by conducting experiments. For experimentation, Kalman observer is used to estimate first three modes and Labview software is used for interfacing intelligent plate to the host PC. Presented strategy can be used to do dynamic vibration testing of a product by

forcing the product to experience same transient vibrations that it is expected to experience while in field.