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A Kalman Estimator-Based Active Vibration Isolation Strategy

A novel, *feed-forward* vibration isolation scheme is developed that addresses the shortcomings of adaptive feedforward vibration isolation algorithms. This scheme which is based on the use of Kalman estimators (KE) does not require real-time adaptation and yet maintains its effectiveness when the attributes (such as the frequencies) of the disturbance changes. More importantly, *it does not require that the disturbance to be periodic.*

The first step in designing the proposed active isolation controller is the design of the KE gains. The plant model used for this purpose is the combination of the transmitted force and structural dynamics models; see the part labeled 'Plant' in Figure 1. The KE should be subject to all the deterministic inputs that the plant is subject to, including the control force. This is why the realization of the structure inside the estimator in Figure 1 is subject to the transmitted force estimated by the estimator, twice. These two forces have the same magnitude and like the two forces acting on the structure they are opposite in sign, zeroing the net force seen by the realization of the structure in the KE. This in turn results in zero estimate for the acceleration. Knowing that the acceleration of the structure estimated by the KE will always be zero, eliminates the need for realizing the structure inside the estimator. *This reduces the computational burden of the KE to the realization of the 2nd order transmitted force block, only, which in turn lowers the complexity of the controller*. Figure 1 shows the block diagram of the controlled system.

Note that the controller consists of the transmitted force model and the KE gain. The structure model (shown in dashed block), being subject to zero net input, does not need to be included in the formulation of the controller.

The effectiveness of the controller is demonstrated experimentally by isolating the mass in a 2nd order system from the vibration of its own base. A shaker is used to input the base vibration disturbance to the plant and a commercially available piezoelectric actuator is used to actively isolate the mass from the base vibration. The frequency response functions mapping the acceleration of the base to that of the mass of the controlled and uncontrolled structure, are measured and presented in Figure 2, indicating the high vibration isolation performance of the controller.

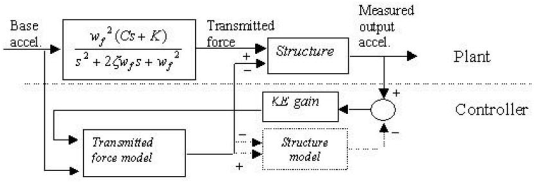

Figure 1. Block diagram of the controlled structure

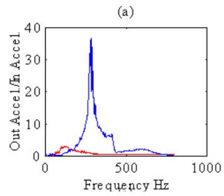

Figure 2. Frequency response functions of the mass acceleration in response to the base acceleration excitations